ANNALS

OF

The Entomological Society of America

VOLUME I, 1908

PUBLISHED QUARTERLY BY THE SOCIETY

COLUMBUS, OHIO, 1908

CONTENTS OF VOLUME I.

Volume I. Number 1.

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MARCH, 1908

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Application made for entry as second class matter, at the P. O. at Columbus, Ohio.

Yours very truly

Saml H. Scudder

Dr. Samuel Hubbard Scudder,
Honorary Fellow, Entomological Society of America.

ANNALS

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The Entomological Society of America

Volume I MARCH 1908 Number 1

INTRODUCTORY

This initial number of the Annals of the Entomological Society of America marks the beginning of an enterprise which it is hoped may become of the greatest value to entomological science in America. Coming as it does as a response to the demand evidenced by a membership of nearly 500 reached within a year from the organization of the society, there is every reason to predict for it a useful service to entomological students.

The scope of the Annals will be as broad as the interests of the Society which it represents but it may not be out of place to emphasize the point that papers dealing with morphologic, faunistic and biologic problems as well as taxonomy in its broadest sense will be especially welcome.

Entomology at the present time is too intimately blended with other branches of science to permit of any narrow limitation for its activities. This Journal can, it is believed, best serve the Society and the science of Entomology at large by furnishing a medium of publication to the varied lines of research concerning insect life and all that pertains thereto. It can serve the progress of biological science in general by stimulating research and discussion concerning those phases of insect life which bear upon the deeper problems of life as a whole. The wealth

of this material is too familiar to most entomologists to need mention but it is only too evident that the opportunity afforded has been too little appreciated by biologists. With a large and enthusiastic body of working entomologists for its support, an unlimited field for original work in the branch of science it represents, and with a growing appreciation of the value of science in general culture, we may predict for the Annals an unlimited growth.

For the sake of a permanent record this number includes the minutes of the meetings already held, copy of the constitution and a list of members. Hereafter these matters doubtless can be condensed into much smaller space and the pages devoted almost entirely to the scientific proceedings of the Society and to original papers.

THE ENTOMOLOGICAL SOCIETY OF AMERICA.

OFFICERS FOR THE YEAR 1907.

(Elected December 28, 1906.)

President .... J. H. COMSTOCK
First Vice President .... JAMES FLETCHER
Second Vice President .... HENRY SKINNER
Secretary-Treasurer .... J. CHESTER BRADLEY

Additional Members of the Executive Committee.

W. M. WHEELER	J. B. SMITH,	C. J. S. BETHUNE,
HERBERT OSBORN,	F. M. WEBSTER,	C. W. JOHNSON.

OFFICERS FOR THE YEAR 1908.

(Elected December 31, 1907.)

President .... WM. M. WHEELER
First Vice President .... J. B. SMITH
Second Vice President .... C. J. S. BETHUNE
Secretary-Treasurer .... J. CHESTER BRADLEY

Additional members of the Executive Committee.

J. H. COMSTOCK,	J. G. NEEDHAM,	P. P. CALVERT,
HERBERT OSBORN,	F. M. WEBSTER,	V. L. KELLOGG.

CONSTITUTION

(Adopted December 28, 1906.)

Article I.

NAME.

Section 1. This organization shall be known as The Entomological Society of America.

Article II.

OBJECTS.

Section 1. It shall be the purpose of this society to promote the science of entomology in all its branches, to secure co-operation in all measures tending to that end, and to facilitate personal intercourse between entomologists.

Article III.

MEMBERSHIP.

Section 1. The membership of this society shall consist of three classes—members, fellows, and honorary fellows.

Sec. 2. All persons interested in entomology shall be eligible to membership.

Sec. 3. Members who have made important contributions to the science of entomology may be elected fellows or honorary fellows of the society.

Article IV.

OFFICERS.

Section 1. The officers of this society shall be a President, two Vice-Presidents, and a Secretary-Treasurer. The duties of these officers shall be those usually pertaining to their respective offices.

Sec. 2. The business of the society not otherwise provided for shall be in the hands of an Executive Committee consisting of the officers named in Section 1, and of six additional members, who shall be elected from the Fellows by the Society. Four members of the committee shall constitute a quorum.

Sec. 3. The President shall represent the society upon the Council of the American Association for the Advancement of Science until such time as the society shall be qualified for representation by two councillors, in which case the second councillor shall be elected from the Fellows by the Executive Committee.

Article V.

ELECTIONS.

Section 1. Election of Members—Nominations for membership may be made by any two members, and election shall be by the Executive Committee.

Sec. 2. Election of Fellows—All nominations for fellows shall be signed by three or more fellows and each nomination shall be accompanied by the following information concerning the nominee: Name, address, occupation, branches of entomology engaged in, positions held involving entomological experience, entomological work done, and list of more important publications. Election shall be by ballot by the Executive Committee, a majority vote of the committee being necessary for election.

Sec. 3. Election of Officers—All officers shall be elected by ballot at the annual meeting for a term of one year, and shall be eligible for re-election. All officers, Secretary-Treasurer excepted, and all additional members of the Executive Committee shall be chosen from the list of Fellows. Provided: The first permanent officers, Secretary-Treasurer excepted, and all additional members of the Executive Committee shall be chosen from members who at the time of their election are Fellows of the American Association for the Advancement of Science.

Sec. 4. Election of Honorary Fellows—All nominations for Honorary Fellows shall be made in the manner prescribed for the nomination of Fellows, the nominations being presented to the Executive Committee, who shall mail the ballots to the Fellows. Election shall be by mail ballot of the Fellows of the society, a two-thirds vote of all the Fellows being required for election.

Article VI.

MEETINGS.

Section 1. An annual meeting shall be held in conjunction with the annual meeting of the American Association for the Advancement of Science, and at such time and place as the officers may elect.

Article VII.

Amendments.

Section 1. This constitution may be altered or amended at any annual meeting by a two-thirds vote of the members present, a copy of each amendment proposed having been presented at the previous annual meeting.

BY-LAWS.

1. The annual dues for members and Fellows shall be one dollar.

2. A majority of the members present at an annual meeting shall constitute a quorum for the transaction of business.

3. Notice of all meetings of the society shall be sent to all members at least one month in advance.

4. The Executive Committee shall provide a program for all meetings, including at the annual meeting a popular lecture and a technical entomological exhibit of materials and methods.

5. The time of the business session shall be published prior to the opening session of the annual meeting.

MEMBERSHIP OF THE SOCIETY.

Honorary Fellows.

(Elected August 21, 1907.)

Ashmead, Dr. William Harris, U. S. Nat. Mus., Washington, D. C.

Cresson, Ezra Townsend, Hedgleigh, Swarthmore, Pa.

Edwards, William Henry, Coalburg, West Virginia.

McCook, Rev. Dr. Henry Christopher, Brookcamp, Devon, Pa.

Scudder, Dr. Samuel Hubbard, 156 Brattle Street, Cambridge Mass.

Uhler, Dr. Philip Reese, 254 W. Hoffman Street, Baltimore, Md.

Ulke, Henry, 411 15th Street, N. W., Washington, D. C.

Fellows.

Aldrich, Prof. J. M., University of Idaho, Moscow, Idaho. Aug. 21, 1907.

Bethune, Rev. Dr. C. J. S., Guelph, Ontario, Canada. Dec. 28, 1906.

Beutenmuller, William, American Museum Natural History, New York City. Aug. 21, 1907.

Bruner, Prof. Lawrence, Lincoln, Neb. Dec. 29, 1907.

Calvert, Dr. P. P., Biological Hall, University of Pennsylvania, Philadelphia. Aug. 21, 1907.

Comstock, Prof. John Henry, Ithaca, N. Y. Dec. 28, 1906.

Coquillett, D. W., Bureau of Entomology, Washington, D. C. Aug. 21, 1907.

Dyar, Dr. Harrison Gray, National Museum, Washington, D. C. Aug. 21, 1907.

Emerton, James H., 194 Clarendon Street, Boston, Mass. Aug. 21, 1907.

Fall, Henry C., 191 N. Raymond Ave., Pasadena, Cal. Dec. 29, 1907.

FERNALD, PROF. CHARLES HENRY, Amherst, Mass. Aug. 21, 1907.

FLETCHER, DR. JAMES, Central Experiment Farm, Ottawa, Canada. Dec. 28, 1906.

FOLSOM, DR. J. W., University of Illinois, Urbana, Illinois. Dec. 29, 1907.

FORBES, DR. S. A., 1209 W. Springfield Avenue, Urbana, Ill. Aug. 21, 1907.

GILLETTE, PROF. C. P., Fort Collins, Col. Dec. 29, 1907.

HENSHAW, SAMUEL, 8 Fayerweather Street, Cambridge, Mass. Aug. 21, 1907.

HOLLAND, DR. W. J., Director of Carnegie Museum, Pittsburg, Pa. Dec. 29, 1907.

HOPKINS, DR. A. D., Washington, D. C. Aug. 21, 1907.

HOWARD, DR. L. O., Department of Agriculture, Washington, D. C. Aug. 21, 1907.

JOHNSON, CHARLES W., Boston Society Natural History, Boston, Mass. Dec. 28, 1906.

KELLOGG, PROF. V. L., Leland Stanford University, Cal. Aug. 21, 1907.

LYMAN, HENRY H., 384 St. Paul Street, Montreal, Quebec. Aug. 21, 1907.

MARLATT, C. L., Bureau of Entomology, Washington, D. C. Dec. 29, 1907.

NEEDHAM, DR. JAMES G., Ithaca, New York. Aug. 21, 1907.

OSBORN, PROF. HERBERT, Ohio State University, Columbus, Ohio. Dec. 28, 1906.

SAUNDERS, DR. WILLIAM, Director Dominion Experiment Farm, Ottawa, Canada. Aug. 21, 1907.

SCHWARZ, E. A., Department of Agriculture, Washington, D. C. Aug. 21, 1907.

SKINNER, DR. HENRY, Logan Square, Philadelphia, Pa. Dec. 28, 1906.

SLINGERLAND, PROF. M. V., Ithaca, New York. Dec. 29, 1907.

SMITH, DR. JOHN B., Agricultural Experiment Station, New Brunswick, N. J. Dec. 28, 1906.

WEBSTER, F. M., U. S. Department of Agriculture, Washington, D. C. Dec. 28, 1906.

WHEELER, DR. WILLIAM MORTON, American Museum Natural History, New York City. Dec. 28, 1906.

Members.

Charter members, unless otherwise indicated.

[1] Signifies that the member was elected Aug. 21, 1907.

[2] Signifies that a member was elected Dec. 29, 1907.

[3] Signifies that a member was elected Dec. 31, 1907.

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*Deceased (Jan. 28, 1908).
†Deceased (Nov. 16, 1907).

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[1]Johnson, Riley O., Chico Normal School, Chico, Cal.
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Jones, Frank Morton, 802 Washington St., Wilmington, Del.

*Died March 11, 1908.

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Keeler, Geo. J., Avon Ave. and Bergen St., Newark, N. J.
Keith, Edward D., 220 Sacket St., Providence, R. I.
Kelleen, John F., 1007½ E. 14th St., Oakland, Cal.
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PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

Minutes of the New York Meeting of December 28, 1906. American Museum of Natural History, New York.

The annual address arranged for by the provisional officers was delivered by Prof. Wm. Morton Wheeler, of the American Museum of Natural History, New York, on *Polymorphism in Ants*, and was illustrated by an extensive and very beautiful series of lantern slides. [A quite full abstract of this address is published in this number of the Annals.]

The business meeting was called to order by Prof. J. H. Comstock, Chairman of the Committee on Organization, and an order of business was adopted.

Prof. Comstock was elected Chairman, and E. S. G. Titus, Secretary, of the Meeting.

The Chairman announced that 216 persons had signified their intention of becoming members of the Society. On motion of Dr. L. O. Howard the Secretary cast the ballot making these persons members of the society.

The Chairman announced that the Committee on Organization were ready to present the constitution for consideration of the members. It was voted to adopt the constitution section by section, as read. Mr. Needham was appointed temporary secretary. Mr. Titus then read the constitution.

Articles I and II adopted as read. Article III, Dr. Skinner proposed an amendment making a third class of members: honorary fellows.

On motion of Prof. H. E. Summers, final consideration of this article was deferred until after passing upon the remainder of the constitution and by-laws.

Articles IV, V, VI, VII and by-laws were adopted with the amendments read by the Secretary.

Consideration of Article III being resumed, Dr. Skinner proposed the following amendments to sections 1 and 3. Section 1 to read "three classes—members, fellows, and honorary fellows." Sec. 3 to read "fellows or honorary fellows of the society."

A motion was carried to reconsider Article V.

Dr. Howard then presented an amendment as follows: "Sec. 4. Election of Honorary Fellows: All nominations for Honorary Fellows shall be made in the manner prescribed for the nominations of Fellows, the nominations being presented to the Executive Committee, who shall mail the ballots to the Fellows. Elections shall be by a mail ballot of the Fellows of the Society, a two-thirds vote of all the Fellows being required for election."

Article V adopted as amended.

The amendment was then adopted.

The constitution and by-laws, as a whole, were then unanimously adopted.

The society then proceeded to the election of officers.

The following officers were elected: President, J. H. Comstock; First Vice President, James Fletcher, Second Vice President, Henry Skinner; Secretary-Treasurer, J. Chester Bradley; the Secretary by vote of the Society casting the ballots for each of them.

The following names were nominated for additional members of the Executive Committee: Wm. M. Wheeler, F. M. Webster, Chas. W. Johnson, J. G. Needham, H. G. Dyar, G. P. Gillette, J. B. Smith, C. J. S. Bethune and Herbert Osborn.

The ballot resulted in the election of Messrs. Wheeler, Smith, Bethune, Osborn, Webster, and Johnson.

The Society then adjourned.

E. G. S. Titus, *Secretary.*

Minutes of the Boston Meeting.

The second meeting of the Entomological Society of America was held in the rooms of the Boston Society of Natural History on the evening of August 22, 1907. The following members were in attendance:

Prof. John Barlow, Kingston, R. I.
Rev. Prof. C. J. S. Bethune, Guelph, Ont.
Mr. William Beutenmuller, New York City.
Mr. C. V. Blackburn, Stoneham, Mass.
Mr. J. Chester Bradley, Berkeley, Cal.
Mr. A. F. Burgess, Boston, Mass.

Mr. Erich Daecke, Philadelphia.
Mr. N. S. Easton, Fall River, Mass.
Mr. J. H. Emerton, Boston, Mass.
Mr. F. P. Engelhardt, Brooklyn, N. Y.
Prof. C. H. Fernald, Amherst, Mass.
Prof. H. T. Fernald, Amherst, Mass.
Mr. W. L. W. Fields, Boston, Mass.
Mr. C. A. Frost, South Framingham, Mass.
Mr. F. Haimbach, Philadelphia, Pa.
Dr. Thomas J. Headlee, Durham, N. H.
Mr. E. F. Hitchings, Waterville, Me.
Dr. W. J. Holland, Pittsburg, Pa.
Mr. C. W. Johnson, Boston, Mass.
Prof. Vernon L. Kellogg, Stanford University, Cal.
Prof. Trevor Kincaid, Seattle, Wash.
Mr. F. E. Lutz, Cold Spring Harbor, N. Y.
Mr. H. H. Lyman, Montreal, Canada.
Mr. B. P. Mann, Washington, D. C.
Mr. C. L. Marlatt, Washington, D. C.
Mr. A. P. Morse, Wellesley, Mass.
Mr. H. H. Newcomb, Boston, Mass.
Prof. Herbert Osborn, Columbus, Ohio.
Prof. R. C. Osburn, New York City.
Miss Edith M. Patch, Orono, Me.
Dr. H. M. Russell, Winchendon, Mass.
Prof. E. D. Sanderson, Durham, N. H.
Dr. Henry Skinner, Philadelphia.
Prof. J. B. Smith, New Brunswick, N. J.
Mr. F. M. Webster, Washington, D. C.
Dr. Wm. Morton Wheeler, New York City.

In addition the following visitors were present:

Dr. G. Horvath, Budapest.
Prof. N. J. Kusnezov, St. Petersburg, Russia.
Prof. G. A. Severin, Bruxelles.
Dr. R. Heymons, Berlin.
Prof. and Mrs. T. D. A. Cockerell, Boulder, Colorado.
Mr. E. C. Cotton, Knoxville, Tenn.
Mr. W. F. Fiske, Washington, D. C.
Mr. J. Arthur Harris, St. Louis, Mo.
Mr. G. V. Pindar, New York City.
Mr. L. R. Reynolds, Boston, Mass.
Mr. A. C. Sampson, Sharon, Mass.
Mr. L. W. Swett, Bedford, Mass.
Mr. A. G. Weeks, Boston, Mass.
Mr. R. H. Wolcott, Lincoln, Neb.
Mr. Chas. Zeleny, Bloomington, Indiana.

In the absence of the President and First Vice President, the Second Vice President, Dr. Henry Skinner, presided. He opened the meeting with words of welcome to the foreign and other guests who were present, many as delegates to the Seventh International Congress of Zoology. Like all new movements this Society had opposition in the inception and there were those who did not see grounds for utility in its existence. Only by trying it can we fairly tell the results. If there were not a demand for such an organization, persons would not be so quick to join, for we already have over 400 members. In the opinion of the speaker, there are a few essential things which such a society should do; for one, to keep amateurs in touch with a central body. Now this very object would be thwarted were the Society to consist, as some have advocated, of delegates from local Societies, because by far the majority of entomologists are not in territory covered by any local society and would be unrepresented. In fact the societies are so few and gathered into such small territory as to be by no means representative. Another great object of such a society is to build up and foster local societies in unoccupied territory. Everyone is familiar with the growth of entomology in the present day. Many of us know the struggles of the older entomologists, and the discredit formerly cast upon their study. As an example of the present day ever-growing interest, the "News" might be mentioned, to refer to a personal subject, which every year has had to be printed in increasing numbers, and already the edition for 1907 is exhausted. The Society was only a natural incident to this increasing growth of entomology, and the speaker is a firm believer in its utility and wishes it a long life and great prosperity.

The Secretary then announced that the following persons had been duly elected Honorary Fellows of the Entomological Society of America:

Ezra Townsend Cresson,	Samuel Hubbard Scudder,
Philip Reese Uhler,	Henry Ulke,
William Henry Edwards,	Henry Christopher McCook,

William Harris Ashmead.

The Secretary further announced that the following sixteen persons had been duly elected to Fellowship in the Entomological Society of America.

John Merton Aldrich,	Andrew Delmar Hopkins,
William Beutenmuller,	Leland Ossian Howard,
Philip Powell Calvert,	Vernon Lyman Kellogg,
Daniel William Coquillet,	William Saunders,
Harrison Gray Dyar,	Eugene Amandus Schwartz,
Charles Henry Fernald,	James George Needham,
Stephen Alfred Forbes,	Henry H. Lyman,
Samuel Henshaw,	James H. Emerton.

Prof. Osborn stated that it was the sense of the Executive Committee by its Committee on Publication that no attempt should be made at the publication of a journal that would occupy the field of any existing serial, and that it does not appear feasible to adopt any of the existing journals as the organ of the Society. It seemed to be the sense of the Committee that a dignified publication might be undertaken in the nature of a series of Annals or Memoirs, but that this should not be done until there was no question as to the permanency of the form in which it be started.

On invitation of the President, Dr. Horvath, Dr. Heymons and Prof. Severin, and later on the invitation of Dr. Holland, Prof. Kusnezov, responded each in turn with a brief address of greeting to the Society.

The Chair remarked that this was sacred entomologic ground, hallowed by the work of Drs. Harris and Scudder. Dr. Scudder's very old friend, Dr. J. G. Holland had been asked to bear him the greetings of the Society, and they now awaited with interest his response from Dr. Holland.

"No more grateful task Mr. President," said Dr. Holland, "could have been imposed upon me than to carry to Dr. Scudder the salutations of the Entomologcial Society of America. This afternoon I made my way to Cambridge, afraid that I might not be permitted to see him, because of the tidings that reached me of his greatly failing health, standing almost as he was within the eternal shadows. What was my satisfaction to be met at the door by his sister, who said he would be very glad indeed to see me. There I found him perfectly helpless in body but perfectly clear in mind. When I told him that I carried to him not only my own greetings, but those of the delegates to the Zoological

Congress and the Entomological Society of America, he replied, 'This is delicious.' He asked me to thank the Society from the fullness of his heart for having remembered an old man, now almost a shadow of his former self."

Dr. Bethune expressed the thanks of the Society to their entertainers in Boston and especially the Cambridge Entomological Club.

Dr. Smith offered a resolution which was heartily concurred in, that the thanks of this Society be expressed to Mr. Kirkland for the wonderful opportunity offered them for observing the experiments being carried on against the gypsy and brown tail moths, etc., at Saugus.

There being no further business the reading of papers was entered upon.

Papers were read as follows:

Dr. J. B. Smith, "Some Unrecognized Sexual Characters of Noctuidae," illustrated by lantern slides. The males of many Noctuids have characteristic tufts and hair pencils on the legs, and these reach their extreme development in the Deltoid series. Many other Noctuidae have hair pencils, brushes and scale tufts concealed in abdominal cavities, and of these little or nothing has been known heretofore. A few of the principal forms were shown on the slides. [Published Trans. Am. Ent. Soc.]

J. Chester Bradley, "A Case of Gregarious Sleeping Habits among Aculeate Hymenoptera." In the San Joaquin Valley this Summer, wasps had been noticed sleeping in bunches. Eight species were represented in considerable numbers, each species always grouped separately.

F. M. Webster, "Parasitism of Toxoptera." Illustrated by drawings to show the various positions assumed by the larva of Lysiphlebus in parasitizing Toxoptera, and causing the latter to assume the characteristic rotund form of parasitized individuals.

Discussion by Drs. Smith and Horvath.

J. Chester Bradley, "The Evolution of the Wings of Evaniidæ." Illustrated by charts. The wings of Evaniidæ portray in a remarkable manner the progress of evolution. From a relatively complex venation we find gradual steps through various degrees of atrophy resulting finally in the almost complete loss of venation. The group probably biphylletic.

Discussion by Dr. Holland and Prof. Kellogg.

W. L. Devereaux, "Slight Climate and Cicindela Faunal Change and extinction." In the absence of the author read by title only.

C. Abbott Davis, "Modern Methods of Mounting Insects." In the absence of the author read by title.

The meeting then adjourned to a smoker at which the Society and its visitors were the guests of the Cambridge Entomological Club, and had a most enjoyable time.

J. Chester Bradley, *Secretary-Treasurer.*

Minutes of the Third Meeting.

The third meeting of the Entomological Society of America was held in the Zoological Building of the University of Chicago, December 30-31, 1907, in affiliation with the American Association for the Advancement of Science and allied societies.

The meeting was called to order by the First Vice President, Dr. Fletcher, at ten o'clock on Monday, December 30, 1907, and immediately adjourned until after the conclusion of the general session of the American Association for the Advancement of Science.

At eleven o'clock the meeting was again called to order, Dr. Fletcher in the chair.

Among those present during the sessions were: C. C. Adams, W. Barnes, C. E. Bartholomew, J. W. Folsom, G. M. Bentley, C. Betten, F. C. Bishop, D. Bodine, J. C. Bradley, W. E. Britton, C. T. Brues, L. Bruner, A. F. Burgess, H. E. Burke, J. H. Cook, M. T. Cook, C. R. Crosby, J. J. Davis, J. H. Emerton, E. P. Felt, H. T. Fernald, J. Fletcher, S. A. Forbes, W. J. Gerhard, J. E. Guthrie, J. L. Hancock, C. A. Hart, T. J. Headlee, W. E. Hinds, J. D. Hood, L. O. Howard, W. D. Hunter, F. Johnson, A. Kwiat, F. E. Lutz, H. H. Lyman, W. S. Marshall, D. Moulton, W. A. Nason, J. G. Needham, H. Osborn, E. M. Patch, J. L. Phillips, A. L. Quaintance, W. A. Riley, A. G. Ruggles, E. D. Sanderson, F. Sherman, Jr., J. B. Smith, R. I. Smith, H. E. Summers, T. B. Symons, W. L. Tower, R. A. Vickery, L. B. Walton, F. L. Washburn, H. E. Weed, H. F. Wickham, C. F. C. Riley, S. W. Williston; James Zetek, B. H. Guilbeau, J. F. Abbott, G. E. Sanders, G. D. Shafer, A. G. Hammar, A. B. Wolcott, E. L. Worsham, W. Newell, J. C. Hambleton, George G. Ainslie, G. P. Weld, J. E. Guthrie, and others.

The meeting proceeded directly to the reading and discussion of papers.

Notes on the Geographical Affinities of the Coleoptera of the Isle Royale, Lake Superior. (An outline of the relations of the Isle Royale beetle fauna to that of northern North America. General remarks on the major faunal centers based on beetles.) C. C. ADAMS.

Dr. Smith asked if there was not a large Carabid element present as Mr. Schwarz had found a very large proportion of these and of Staphylinidæ along the shores of Lake Michigan, and from the way Mr. Adams said the fauna had been derived one would expect the same on the Isle Royale. Mr. Adams said that that was the case. Dr. Fletcher asked if Mr. Adams had applied names to his areas. Mr. Adams had not, but he did not accept the zonal divisions of Merriam, since they did not hold for beetles.

Some Problems in Nomenclature. (A brief discussion of the validity of names, particularly those bestowed on Insect galls and larvæ). DR. E. P. FELT.

Prof. Hart asked what should be done with galls from which the adult insects were unknown. Dr. Felt would give them tentative names. Dr. Needham said that names of galls were of a different sort from those bestowed upon plants and animals and should not enter our zoological systems. Mr. Bradley added that English names, if used for galls, would avoid the confusion that the introduction of Latin names causes. He objected to even the tentative use of binomials.

Stereoscopic Photography applied to Entomological Subjects. PROF. F. L. WASHBURN.

Discussion by Messrs. Hinds and Summers. Mr. Bradley mentioned a very simple device which Mr. Crosby and he had used in obtaining good stereoscopic effects in photographing insects. It consisted of an ordinary camera having a brass diaphragm that could be reversed, and the aperture made eccentric. One exposure was made with the aperture on one side, and another with the aperture on the opposite side, the result giving an excellent stereoscopic effect.

Life history and habits of the Dimorph of Chaitophorus negundinis. Thos. (Previous knowledge of the dimorph. Comparison with a similar dimorph in Europe. Life history; appearance in summer. Part played in the survival of the species, etc.) J. J. DAVIS.

Discussion by Dr. Headlee and Dr. Fletcher.

Is Mutation a factor in the production of Vestigial Wings among Insects? (A summary of some observations among insects belonging to various groups, where the evolution of wingless or subapterous species can be traced within a group). C. T. BRUES. (To be published in Jour. N. Y. Ent. Soc.)

Mr. Hinds asked if Mr. Brues had paid attention to the winged condition in Thysanoptera. There one finds dimorphism due to season. There is no relation between the short winged and entirely apterous forms, but the same species will show short and long winged individuals. The paper was further discussed by Messrs. Smith, Bruner and Cook.

The meeting then adjourned until 1:30.

The afternoon session was opened by the reading of a paper by Dr. W. A. RILEY, entitled, *External Wing Buds in the Larva of Holometabolous Insects*. (A brief discussion of the general subject and recorded insects, and a report of an unrecorded instance.) (Published Entomological News, March, 1908.)

Dr. Needham said that he had never found any trace of external wings in the Larva of Diptera of Neuroptera that he had examined.

Notes on the Nervous System of the Cordyalis larva. A. G. HAMMAR.

Dr. Riley remarked that such work showed the need for careful studies of the nervous system of insects. He suggested that by tracing out the proper nerve Mr. Hammar might be able to locate the salivary gland, which no one had yet succeeded in doing. Dr. Smith asked Mr. Hammar for his technique. Fresh material was used hardened in Gilson's fluid and stained in picric acid. The incision is made on the dorsal side, and the dissection made under water, the larva being pinned to cork.

In the absence of the author, a paper by Dr. A. Petrunkevitch entitled, "*The Sense of Sight in Spiders*," was read by title only. (To be published in Journal Exp. Zool.)

Dr. Riley moved that nominations for President and First and Second Vice President, Secretary-Treasurer and the six additional members of the Executive Committee be by ballot, to be signed and handed in to the Secretary before 11 A. M., Tuesday, and that from the names so placed in nomination, the four leading each list be finally balloted upon, except that in the case of the Executive Committee, the first twelve be considered.

Seconded and after discussion carried.

The meeting then adjourned until after the conclusion of the address by Vice President Conklin before Section F., of the American Association for the Advancement of Science.

Upon reconvening, Mr. C. R. Crosby read a paper entitled, "*Notes on a Chalcid infesting an Apple-seed.*"

Prof. Bruner said that the species certainly was of much importance from a horticultural standpoint. Dr. Smith said he thought they might have been imported. Mr. Crosby said he had found them generally distributed over the state of New York. Dr. Howard felt certain that they had been imported. The discovery that Syntomaspis is phytophagous is one," he said, "of very great interest." Some time ago Mr. Banks had called the speaker's attention to the work of Motschulsky referred to by Mr. Crosby, and later on visiting Crimea he had seen Motschulsky's specimens. An assistant in the U. S. Bureau of Entomology has found what are probably the larvæ of this species in the seeds of an imported Russian haw. Dr. Fletcher said that in the past many apple seeds had been imported from Russia, and that he thought the insects might have entered in that way.

Dr. J. G. Needham read a paper entitled, "*The New Biological Field Station at Cornell University.*"

"*The mouth parts and phylogeny of the Siricoidea.*" J. Chester Bradley. Discussion by Dr. Smith and Dr. Riley.

"*Is Vespa borealis an Inquiline?*" (An account of finding males and females of Vespa borealis living together apparently on friendly terms.) Dr. James Fletcher.

Discussion by Mr. Brues and Dr. Smith. Dr. Fernald said that no worker of borealis had been described, and that two European species of Vespa were known to have a similar habit.

"*On certain Structural Characters of the genus Catocala.*" W. Beutenmuller. Read by title.

"*The Entomological Society of America and its work.*" H. H. Lyman.

"*The Habits of the Crane-fly Dicranomyia defuncta* O. S." Dr. J. G. Needham.

"*The Life history of a Bee fly, Spogostylum anale.* Say." (The larvæ parasitic on the larvæ of a tiger beetle, Cicindela scutellaris. Say. Eggs laid in July or August; larvæ on the last larval stage of the host in Spring; when host makes its pupal cell

and the internal parts become semi-fluid, the parasite moults and grows very rapidly completely destroying the host, (July). The pupa digs toward the surface by wriggling movements of the body, and the adult emerges when the surface is reached). V. E. Shelford. Read by title.

"*Circumfili in the Cecidomyiidæ.*" (A discussion of the morphology and taxonomic value of these organs). Dr. E. P. Felt.

Dr. Riley thought that Dr. Felt's second explanation was correct,—that the circumfili are modified hairs.

"*Ancestral Ephemeridæ from the American Permian formation.*" (A group of true Ephemeridæ obtained from the Permian of Kansas. The earliest known true Ephemerids, and with the exception of a few Russian specimens, all that are known from the Permian. They present a distinct early stage in the evolution of the Ephemerid line). Dr. E. H. Sellards. Title only.

Mr. Kwiat described the collecting grounds around Chicago.

Mr. J. H. Cook read a paper on the habits of the larvæ of Lycæna.

The meeting then adjourned until 11 o'clock on the following day.

At eight P. M. the annual address before the Society was given in the botanical lecture room of the University by Prof. Herbert Osborn, entitled, "The Habits of Insects as a Factor in Classification."

Afterwards the Society and their guests were entertained by the Entomological Section of the Chicago Academy of Science at a very enjoyable smoker.

Business Meeting.

On Tuesday, Dec. 31, at 11 A. M., the annual business meeting was held, Dr. Fletcher in the chair.

The Secretary read the minutes of the last annual meeting, also of the special meeting held in Boston in August. These were adopted as read.

The Secretary read a report from the Executive Committee embracing statement of accounts, the election of members and Fellows at the last meeting of the Committee, and a series of resolutions on publication adopted by the Committee from the report of their committee on publication.

These items were as follows:

Financial Statement, December 31, 1907.

EXPENDITURES.		RECEIPTS.	
Stamps	$ 64.77	Fees for 1907	$382.90
Committee on Organization	43.08	Fees for 1908	7.00
Telegram	.27	Fees due upon election	5.00
Rubber stamp, etc	4.15	Miscellaneous	5.15
Printing	128.65		
Clerks	18.30		
Stationery	5.70		
Expressage	5.75		
Total	$270.67		
	129.38		
Total	$400.05	Total	$400.05

LIABILITIES.		ASSETS (CASH.)	
Fees for 1908 of 7 members	$ 7.00	Refund on expressage	$ 3.00
Fees due upon election of 5 persons	5.00	Dues for 1907 of 39 members	39.00
		Balance from one member	.10
Total liabilities	$ 12.00	Total assets	42.10
		Liabilities	12.00
		Balance	$ 30.10
		Cash on hand	129.38
		Total Resources	$159.48

Accounts examined and found correct.

[Signed.] H. Osborn,
J. B. Smith.

ELECTION OF THE FOLLOWING TO MEMBERSHIP.

G. E. Sanders, Urbana, Ill.; G. D. Shafer, Ithaca, N. Y.; J. A. Nelson, Ithaca, N. Y.; A. G. Hammar, Ithaca, N. Y.; Wm. H. Blatchley, Indianapolis, Ind.; A. B. Wolcott, Chicago, Ill.; E. L. Worsham, Atlanta, Ga.; R. W. Harned, Agricultural College, Miss. Alex. Petrunkevitch, Short Hills, N. J.; T. D. A. Cockerell, Boulder, Colo.; W. Newell, Baton Rouge, La.; J. C. Hambleton, Columbus, O.; George Ainslee, St. Anthony Park, Minn.; G. P. Weld, Evanston, Ill.

ELECTION OF THE FOLLOWING FELLOWS.

Mark Vernon Slingerland; Justus Watson Folsom; William Joseph Holland; Clarence Preston Gillette; Henry Clinton Fall; Charles Lester Marlatt; Lawrence Bruner.

THE FOLLOWING RESOLUTIONS ON PUBLICATION.

1. That the Society undertake a publication to be called Annals of the Entomological Society of America, to be issued in quarterly fascicles.

2. That it include only papers of importance or marked merit, and that each be issued and bound separately as well as in facsicles so that each paper may be sold separately.

3. That proceedings of the meetings be included either at the beginning or the end of each volume and form one separate which is to be sent to all members of the Society.

4. That a subscription price of One Dollar in addition to the membership fee be charged to members for the Annals and that the subscription price to non- members, libraries, etc., be Three Dollars.

5. That an Editorial Board be selected by the Executive Committee and that this Board shall select one of its members as Managing Editor who with his Associates shall be responsible for the selection of material to be published.

6. That if possible some one living in a suitable location and who can undertake the work of Managing Editor for a series of years, be selected for this position.

7. That details not covered in this report are to be determined by the Editorial Board.

8. That actual publication under the provisions of this report be inaugurated as soon as possible.

Moved by Dr. Smith and seconded by Prof. Sanderson that the report be adopted. Dr. Needham moved to amend, to adopt report except the articles on publication. Motion carried as amended. Dr. Howard moved the adoption of the resolutions on publication, and this was seconded.

Dr. Needham asked where the funds were coming from. Prof. Osborn stated that the subscription plan embodied in the report was counted upon to provide these, but that the date of starting publication was left to the judgment of the committee, and need not be done until the funds were guaranteed. Prof. Sanderson asked what estimate was placed upon the cost of publication. Prof. Osborn said, roughly, $1.000. Dr. Smith said that there were no obligations imposed as to size, and that members would receive the proceedings of the meetings without extra cost, but would pay for the remainder. The idea was the outcome of the

almost universal demand for something of the sort to hold the membership together. In response to question from Mr. Hammar, the Chair stated that it was provided that the Executive Committee should elect the Board of Editors, and Dr. Smith remarked that they need not be members of the Committee, nor necessarily Fellows of the Society.

The motion to adopt the resolution on publication embodied in the report of the Executive Committee was then passed.

The Secretary announced the death of E. H. Davis, of Honolulu, a charter member of this Society.

Dr. Fernald moved:

1. That the Entomological Society of America hereby endorses the Code of Nomenclature adopted by the International Zoological Congress as the Code which should be used by the members of the Society so far as it can be applied.

2. That cases not covered by this Code, which may be presented to the Society for consideration, be referred to a Standing Committee on Nomenclature to consist of three members, one member of which shall be elected each year for a term of three years, and the opinions of this committee on cases referred to them, shall be reported to the Society at the first annual meeting subsequent to their reference to the Committee.

Seconded by Dr. Smith.

Dr. Fernald stated that we could either individually or as a body present such questions to the Zoological Congress.

Mr. Bradley moved to amend by dropping the second clause, "because," he said, "Entomology should not be treated as distinct from Zoology in general, and because the commission on Nomenclature of the Zoological Congress is the sufficient and proper body before which to bring such questions for decision."

Prof. Fernald stated that the reports of the Commission on Nomenclature of the International Congress were greatly delayed by the fact that the congress met only once in three years and by the rule that a question must be presented at least a year before the meeting at which it is to be considered. It was not the intention of the motion that the Committee should act in opposition to or independently of the Commission on Nomenclature, but that it should be instrumental in voicing the needs of entomology before that body, which should be the final court of reference.

With that explanation the amendment was withdrawn. Resolution passed.

Prof. Washburn moved that it is the sense of this meeting that fellowship for the present be limited to ten per cent. of the membership.

Dr. Smith said that the Executive Committee had experienced much difficulty in drawing the line in regard to fellowship. They hoped for some guidance from the Society and a certain limit beyond which they might not pass.

Prof. Summers believed in limiting the number as far as possible. Dr. Felt pointed out that the constitution seems to indicate that a Fellow should be elected on account of strong merit, and that a definite number would not help matters. Several of our present Fellows were unavailable for office and we had but few from whom to select officers.

Dr. Fletcher said that he felt we needed more active men on the list.

Dr. Smith said that there were other men in the Society who were fit to be Fellows, but that the question to decide was whether the list should be a large one from which to draw officers, or a small one for honor.

Prof. Sanderson suggested that some of the present list might be made Honorary Fellows.

Mr. Bradley asked whether a constitutional amendment, providing that members of the Executive Committee need not be drawn from the list of Fellows, would be of any aid.

Dr. Felt said that he thought Honorary Fellows should be very limited and a great honor, but that ordinary Fellows were more like those of the A. A. A. S. and that there was strength in a large number.

Division was called upon Dr. Washburn's motion, and upon show of hands the motion was declared passed.

The Chairman read to the Society a part of a letter from Dr. S. H. Scudder of Cambridge, in which he said, "Please bear my greetings to my good Entomological friends at the Chicago meeting of the Entomological Society of America." The keen interest felt in the Society by Dr. Scudder was mentioned.

The following nominations for officers received in accordance with Dr. Riley's motion, were posted.

President, Dr. J. B. Smith, Dr. Wheeler, Dr. L. O. Howard, Dr. Fletcher.

First Vice President, Dr. Smith, Dr. Skinner, Dr. Wheeler, Dr. Fletcher.

Second Vice President, Dr. Forbes, Dr. Folsom, Dr. Bethune, Dr. J. B. Smith.

Secretary-Treasurer, Dr. Needham, Mr. Adams, Mr. Bradley.

Executive Committee, Drs. Needham, Calvert, Folsom, Fletcher, J. B. Smith, Skinner, Profs. H. Osborn, Comstock, Kellogg, Gillette and Bruner, and Mr. F. M. Webster.

The ballots were then taken and the meeting adjourned until after lunch, Prof. Summers and Dr. Betten acting as tellers.

At 1:45 the meeting was again called to order. The Secretary announced that the following officers had been elected:

President, Dr. W. M. Wheeler.

First Vice President, Dr. J. B. Smith.

Second Vice President, Rev. Prof. C. J. S. Bethune.

Secretary-Treasurer, J. C. Bradley.

Additional members of the Executive Committee:—Prof. J. H. Comstock, Dr. J. G. Needham, Dr. P. P. Calvert, Prof. Herbert Osborn, Mr. F. M. Webster, Prof. V. L. Kellogg.

Dr. Smith offered the following resolution which was adopted:

Resolved, that the thanks of this Society be extended to the University of Chicago for the accommodations furnished and courtesies offered to it, and

Resolved, further, that the thanks of this Society be extended to the Entomological Section of the Chicago Academy of Sciences and to its members individually for the entertainment given to our Society and its members during the meeting.

Mr. Weed moved that Prof. H. T. Fernald be elected member of the Committee on Nomenclature to serve for three years. Seconded by Bradley. Carried.

Mr. Bradley moved that Prof. T. D. A. Cockerell be elected a member of this Committee to serve for two years. Seconded by Mr. Ruggles. Carried.

Dr. Smith moved that Dr. Felt be elected member to serve for one year. Seconded by Prof. Washburn. Carried.

The meeting discussed informally several Entomological topics while awaiting the arrival of Mr. C. F. Jackson, who had a paper entitled, "*Observations on the Life History and Adaptation of a new semi-aquatic Aphid.*" (Habits, life history and specialization of Aphis aquaticus nov. found on water thyme; many remarkable adaptations to its semi-aquatic life). [Published *Ohio Naturalist*, Jan., 1908.]

As Mr. Jackson did not appear the paper was read by title only and the meeting adjourned sine die.

J. Chester Bradley, *Secretary-Treasurer*.

During the session an exhibit of entomological specimens and materials was open for the inspection of those interested. The titles of the exhibit are given below:

Some enlarged Photographs of Fossil Insects. Chas. T. Brues.

New Devices in Economic Entomology. W. E. Hinds.

Stereoscopic Pictures of Insects. Professor F. L. Washburn.

Dimorph of Chaitophorus negundinis Thos. John J. Davis.

Case of Fall Webworm Moths (Hyphantria textor and H. Cunea). Showing range of Variation of the Latter; Inflated Larvæ. Henry H. Lyman.

Entomological Specimens and Equipment; Interesting Insects from Mexico, Cuba, and Indo-Australia; New Species of Dynastes, etc. Dr. G. Lagai.

Stereoscopic Photographs of Oryssidæ Taken with the Camera Attachment to the Zeiss Greenough Binocular Microscope. Mouth parts of Siricidæ. J. Chester Bradley.

Stereoscopic Photograph of a Tenebrionid Beetle Taken with an Ordinary Camera Using an Eccentric Diaphragm. C. R. Crosby and J. C. Bradley.

The portrait of Dr. Scudder which forms the frontispiece for this number, will certainly be a welcome sight to all our members whether they have had the privilege of personal acquaintance with him or not. "It was taken by a friend one summer afternoon as he sat reading on the veranda. It is the latest picture and the best."

NOTES ON A CHALCID (Syntomaspis druparum Boh.) INFESTING APPLE SEEDS.

By Cyrus R. Crosby, Cornell University, Ithaca, N. Y.

(Abstract.)

On July 27, 1906, while examining some crab apples at Ithaca, N. Y., for the apple maggot, Rhagolitis pomonella Walsh, the writer noticed that many seeds contained a small Hymenopterous larva. It occupied only a small portion of the interior and was evidently devouring the kernel. During the remainder of the summer the seeds were examined at frequent intervals, and it was found that the larvæ gradually increased in size while the kernel slowly disappeared until in September the larva alone occupied the cavity of the seed.

Egg-laying was not observed, but as the female is provided with a long ovipositor it is probable that the eggs are inserted directly into the young seed while the apple is very small. The full-grown larva passes the winter in the seeds and in May pupates. The adults appeared in June. Specimens were sent to Dr. L. O. Howard who determined them as probably Syntomaspis druparum Boh.

An account of the occurrence of this insect in Crimea where it infests the seeds of the wild apple has been published by Sigismond Mokshetsky (Ztschr. Wiss. Insbiol., II, pp. 390–392, 1906) under the name of Syntomaspis pubescens Forst. I have compared adults reared at Ithaca with specimens kindly sent me by Mokshetsky and find that they are without doubt the same species.

This insect is of interest not only on account of its being the only representative of the genus known to be phytophagic in the larval state, the other species being parasites, but also because it may possibly become an important horticultural pest. It is generally distributed in New York State and infests the native wild apple, Malus coronaria, as well as a number of cultivated varieties.

THE POLYMORPHISM OF ANTS.*

By William Morton Wheeler.

There is a sense in which the term polymorphism is applicable to all living organisms, since no two of these are ever exactly alike. But when employed in this sense, the term is merely a synonym of "variation," which is the more apt, since polymorphism has an essentially morphological tinge, whereas variation embraces also the psychological, physiological, and ethological differences between organisms. In zoölogy the term polymorphism is progressively restricted, first, to cases in which individuals of the same species may be recognized as constituting two or more groups, or castes, each of which has its own definite characters or complexion. Second, the term is applied only to animals in which these intraspecific groups coexist in space and time and do not arise through metamorphosis or constitute successive generations. Cases of the latter description are referred to "alternation of generations" and "seasonal polymorphism." And third, the intraspecific groups which coincide with the two groups of reproductive individuals in all gonochoristic, or separate-sexed Metazoa are placed in the category of "sex" or "sexual dimorphism." There remain, therefore, as properly representing the phenomena of polymorphism only those animals in which characteristic intraspecific and intrasexual groups of individuals may be recognized, or, in simpler language, those species in which one or both of the sexes appear under two or more distinct forms.

As thus restricted polymorphism is of rare occurrence in the animal kingdom and may be said to occur only in colonial or social species where it is commonly attributed to a physiological division of labor. It attains its clearest expression in the social insects, in some of which, like the termites, we find both sexes equally polymorphic, while in others like the ants, social bees, and wasps, the female alone, with rare exceptions, is differ-

* Abstract of an address before the Entomological Society of America December 28, 1906, and published in full in the Bulletin of the American Museum of Natural History, Vol. XXIII, Article I, Jan. 15, 1907, pp. 1–93, pll. I–VI. Only the more general considerations are embodied in this abstract; for a detailed account of the effects of Orasema, Lomechusa, Xenodusa and Mermis parasitism in ants, the reader is referred to the complete work.

entiated into distinct castes. This restriction of polymorphism to the female in the social Hymenoptera, with which we are here especially concerned, is easily intelligible if it be traceable, as is usually supposed, to a physiological division of labor, for the colonies of ants, bees, and wasps are essentially more or less permanent families of females, the male representing merely a fertilizing agency temporarily intruding itself on the activities of the community at the moment it becomes necessary to start other colonies. We may say, therefore, that polymorphism among social Hymenoptera is a physical expression of the high degree of social plasticity and efficiency of the female among these insects. This is shown more specifically in two characteristics of this sex, namely the extraordinary intricacy and amplitude of her instincts, which are thoroughly representative of the species, and her ability to reproduce parthenogenetically. This, of course, means a considerable degree of autonomy even in the reproductive sphere. But parthenogenesis, while undoubtedly contributing to the social efficiency of the female, must be regarded and treated as an independent phenomenon, without closer connection with polymorphism, for the ability to develop from unfertilized eggs is an ancient characteristic of the Hymenoptera and many other insects, which made its appearance among the solitary species, like the Tenthredinidæ and Cynipidæ, long before the development of social life. Moreover, polymorphism may occur in male insects which, of course, are not parthenogenetic. That parthenogenesis is intimately connected with sexual dimorphism, at least among the social Hymenoptera, seems to be evident from the fact that the males usually if not always develop from unfertilized, the females from fertilized eggs.

While the bumble-bees and wasps show us incipient stages in the development of polymorphism, the ants as a group, with the exception of a few parasitic genera that have secondarily lost this character, are all completely polymorphic. It is conceivable that the development of different castes in the female may have arisen independently in each of the three groups of the social Hymenoptera, although it is equally probable that they may have inherited a tendency to polymorphism from a common extinct ancestry. On either hypothesis, however, we must admit that the ants have carried the development of the female castes much further than the social bees and wasps, since they have not only produced a wingless form of the worker, in addition to the winged

female, or queen, but in many cases also two distinct castes of workers known as the worker proper and the soldier.

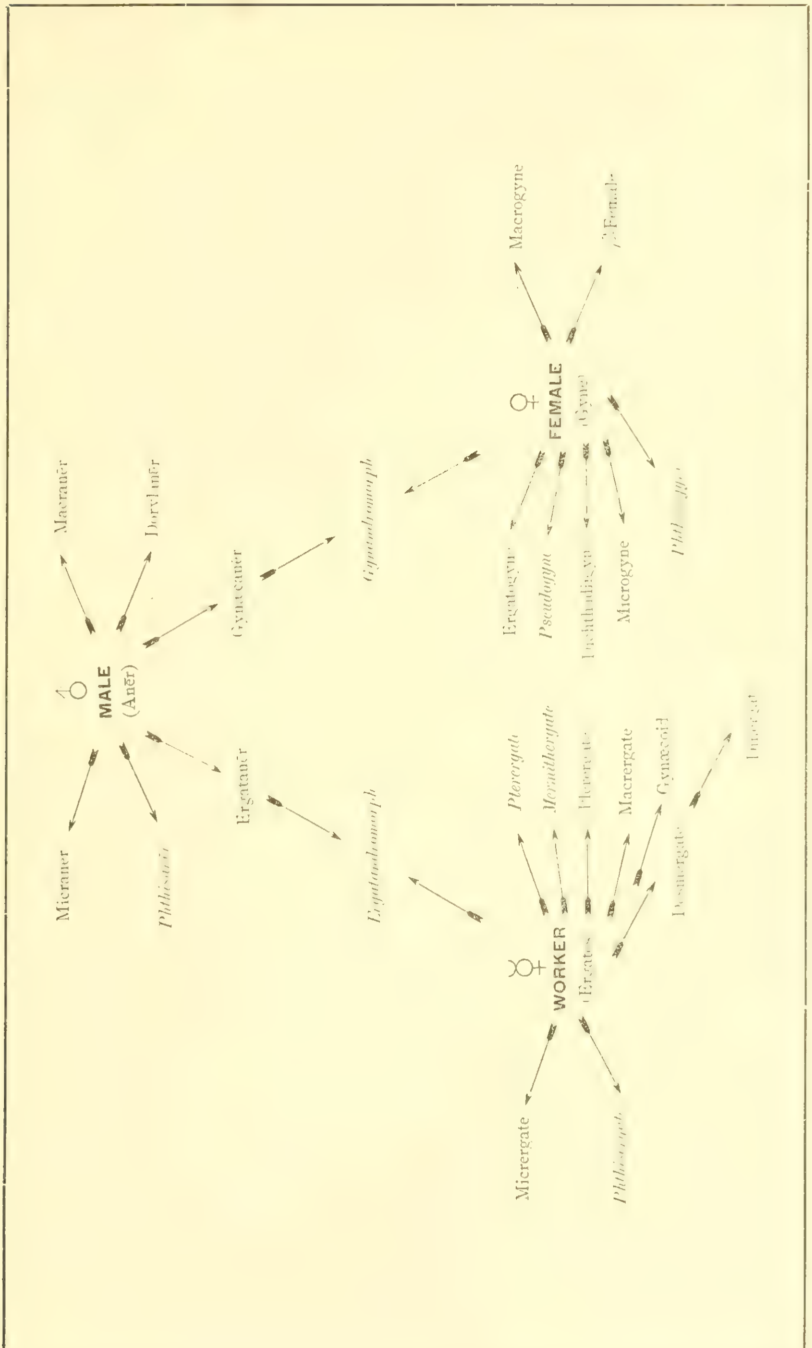
Different authors have framed very different conceptions of the phylogenetic beginnings of social life among the Hymenoptera and consequently also of the phylogenetic origin and development of polymorphism. Thus Herbert Spencer (1893) evidently conceived the colony as having risen from a consociation of adult individuals and although he unfortunately selected a parasitic ant, the amazon (Polyergus rufescens), on which to hang his hypothesis, there are a few facts which seem at first sight, to make his view applicable to other social Hymenoptera. Fabre (1894) once found some hundreds of specimens of a solitary wasp (Ammophila hirsuta) huddled together under a stone on the summit of Mt. Ventoux in the Provence at an altitude of about 5,500 feet, and Forel (1874) found more than fifty deälated females of Formica rufa under similar conditions on the Simplon. I have myself seen collections of a large red and yellow Ichneumon under stones on Pike's Peak at an altitude of more than 13,000 feet, and a mass of about seventy deälated females of Formica gnava apparently hibernating after the nuptial flight under a stone near Austin, Texas. I am convinced, however, that such congregations are either entirely fortuitous, especially where the insects of one species are very abundant and there are few available stones, or that they are, as in the case of F. rufa and gnava, merely a manifestation of highly developed social proclivities and not of such proclivities in process of development.

A very different view from that of Spencer is adopted by most authors, who regard the insect society as having arisen, not from a chance concourse of adult individuals but from a natural affiliation of mother and offspring. This view, which has been elaborated by Marshall (1889) among others, presents many advantages over that of Spencer, not the least of which is its agreement with what actually occurs in the founding of the existing colonies of wasps, bumble-bees and ants. These colonies pass through an ontogenetic stage which has all the appearance of repeating the conditions under which colonial life first made its appearance in the phylogenetic history of the species—the solitary mother insect rearing and affiliating her offspring under conditions that would seem to arise naturally from the breeding habits of the nonsocial Hymenoptera. The exceptional methods of colony formation seen in the swarming of the honey bee

and in the temporary and permanent parasitism of certain ants, are too obviously secondary and of too recent a development to require extensive comment. The bond which held mother and daughters together as a community was from the first no other than that which binds human societies together—the bond of hunger and affection. The daughter insects in the primitive colony became dependent organisms as a result of two factors: inadequate nourishment and the ability to pupate very prematurely. But this very ability entailed an incompleteness of imaginal structure and instincts, which in turn must have confirmed the division of labor and thus tended to perfect the social organization.

Before further discussing the problems suggested by this view of the origin of the colony and the general subject of polymorphism it will be advisable to pass in review the series of different phases known to occur among ants. This review will be facilitated by consulting the accompanying diagram, in which I have endeavored to arrange the various phases so as to bring out their morphological relations to one another. The phases may be divided into two main groups, the normal and the pathological. In the diagram the names of the latter are printed in italics. The normal phases may be again divided into primary or typical, and secondary or atypical, the former comprising only the three original phases, male, female, and worker, the latter the remaining phases, which, however, are far from having the same status or frequency. The three typical phases are placed at the angles of an isosceles triangle, the excess developments being place to the right, the defect developments to the left, of a vertical line passing through the middle of the diagram. The arrows indicate the directions of the affinities of the secondary phases and suggest that those on the sides of the triangle are annectant, whereas those which radiate outward from its angles represent the new departures with excess and defect characters.

(1) The **male (aner)** is far and away the most stable of the three typical phases which are found in all but a few monotypic and parasitic genera of ants. This is best shown in the general uniformity of structure and coloration which characterize this sex in genera whose female forms (workers and queens) are widely different; e. g., in such a series as Myrmecia, Odontomachus, Cryptocerus, Formica, Pheidole, etc. In all of these genera the males are very similar, at least superficially, whereas the



THE TYPICAL, ATYPICAL AND PATHOLOGICAL PHASES OF ANTS.

workers and females are very diverse. The body of the male ant is graceful in form, one might almost say emaciated. Its sense-organs (especially the eyes and antennæ), wings and genitalia are highly developed; its mandibles are more or less imperfectly developed and in correlation with them the head is proportionally shorter, smaller and rounder than in the females and workers of the same species. Even when the latter phases have brilliant or metallic colors, as in certain species of Macromischa and Rhytidoponera, the males are uniformly red, yellow, brown or black. Yet notwithstanding this monotony of structure and coloration, the male type may present several interesting modifications.

(2) The **macraner** is an unusually large form of male which occasionally occurs in populous colonies.

(3) The **micraner,** or dwarf male, differs from the typical form merely in its smaller stature. Such forms often arise in artificial nests.

(4) The **dorylaner** is an unusually large form peculiar to the driver and legionary ants of the subfamily Dorylinæ (Dorylus and Eciton). It is characterized by its large and peculiarly modified mandibles, long cylindrical gaster and singular genitalia. It may be regarded as an aberrant macraner that has come to be the typical male of the Dorylinæ.

(5) The **ergataner**, ergatomorphic, or ergatoid male resembles the worker in having no wings and in the structure of the antennæ. It occurs in the genera Ponera, Formicoxenus, Symmyrmica and Cardiocondyla. In certain species of Ponera (P. punctatissima and ergatandria) and in Formicoxenus nitidulus the head and thorax are surprisingly worker-like, in other forms like Symmyrmica chamberlini these parts are more like those of the ordinary male ant, while P. eduardi shows an intermediate development of the head with a worker-like thorax. Forel (1904) has recently found that the ergataner may coexist with the aner, at least in one species of Ponera (P. eduardi Forel). In other words, this ant has dimorphic males.

(6) The **gynæcaner**, or gynæcomorphic male occurs in certain parasitic and workerless genera (Anergates and Epœcus) and resembles a female rather than a worker form. The male of Anergates is wingless, but has the same number of antennal joints as the female. In Epœcus both sexes are very much alike and both have 11–12 jointed antennæ (Emery 1906).

(7) The **phthisaner** is a pupal male which in its larval or semipupal state has its juices partially exhausted by an Orasema larva. This male is too much depleted to pass on to the imaginal stage. The wings are suppressed and the legs, head, thorax, and antennæ remain abortive.

(8) The **female (gyne),** or queen, is the more highly specialized sex among ants and is characterized, as a rule, by her larger stature and the more uniform development of her organs. The head is well developed and provided with moderately large eyes, ocelli, and mandibles; the thorax is large (macronotal) and presents all the sclerites of the typical female Hymenopteron; the gaster is voluminous and provided with well developed reproductive organs. The latter possess a receptaculum seminis. The wings and legs are often proportionally smaller than in the male.

(9) The **macrogyne** is a female of unusually large stature.

(10) The **microgyne,** or dwarf female, is an unusually small female which in certain ants, like Formica microgyna and its allies, is the only female of the species and may be actually smaller than the largest workers. In other ants, like certain species of Leptothorax and Myrmica, microgynes may sometimes be found in the same nests as the typical females.

(11) The **β–female** is an aberrant form of female such as occurs in Lasius latipes, either as the only form or coexisting with the normal female, which is then called the α-female. In this case, therefore, the female is dimorphic. The β-female is characterized by excess developments in the legs and antennæ and in the pilosity of the body, or by defective development of the wings.

(12) The **ergatogyne,** ergatomorphic, or ergatoid female, is a worker-like form, with large eyes, ocelli, and a thorax more or less like that of the female, but without wings. Such females occur in a number of species of ants. They have been seen in Myrmecia, Odontomachus, Anochetus, Ponera, Polyergus, Leptothorax, Monomorium and Cremastogaster. There is nothing to prove that they are pathological in origin. In fact, in Monomorium floricola, and certain species of Anochetus they appear to be the only existing females. In other cases, like Ponera eduardi, as Forel has shown, they occur with more or less regularity in nests with normal workers. They also occur under similar conditions in colonies of the circumpolar P. coarctata, and probably also among other species of the genus.

(13) The **pseudogyne** is a worker-like form with enlarged mesonotum and sometimes traces of other thoracic sclerites of the female but without wings or very rarely with wing vestiges. This form occurs in Formica colonies infested with parasitic beetles of the genera Lomechusa and Xenodusa.

(14) The **phthisogyne** arises from a female larva under the same conditions as the phthisaner, and differs from the typical female in the same characters, namely absence of wings, stenonoty, microcephaly and microphthalmy. It is unable to attain to the imaginal instar.

(15) The **worker** (**ergates**) is characterized by the complete absence of wings and a very small (stenonotal) thorax, much simplified in the structure of its sclerites. The eyes are small and the ocelli are usually absent or, when present, extremely small. The gaster is small owing to the undeveloped condition of the ovaries. A receptaculum seminis is usually lacking, and the number of the ovarian tubules is greatly diminished. The antennæ, legs and mandibles are well developed.

(16) The **gynæcoid** is an egg-laying worker. It is a physiological rather than a morphological phase, since it is probable that all worker ants when abundantly fed become able to lay eggs. Wasmann (1904) observed in colonies of Formica rufibarbis that a few workers became gynæcoid and functioned as substitution queens. In colonies of the Ponerine genus Leptogenys (including the subgenus Lobopelta), and probably also in Diacamma and Champsomyrmex, the queen phase has disappeared and has been replaced by the gynæcoid worker.

(17) The **dichthadiigyne,** or dichthadiiform female is peculiar to the ants of the subfamily Dorylinæ, and probably represents a further development of the gynæcoid. If this view of the origin of the dichthadiigyne is held, the name of this form in the diagram should be transferred to the worker side. It is wingless and stenonotal, destitute of eyes and ocelli, or with these organs very feebly developed, and with a huge elongated gaster and extraordinary, voluminous ovaries.

(18) The **macrergate** is an unusually large worker form which is sometimes produced in populous or affluent colonies (Formica, Lasius).

(19) The **micrergate**, or dwarf worker, is a worker of unusually small stature. It appears as a normal or constant form in the first brood of all colonies that are founded by isolated females.

(20) The **dinergate,** or soldier, is characterized by a huge head and mandibles, often adapted to particular functions (fighting and guarding the nest, crushing seeds or hard parts of insects), and a thoracic structure sometimes approaching that of the female in size or in the development of its sclerites (Pheidole).

(21) The **desmergate** is a form intermediate between the typical worker and dinergate, such as we find in more or less isolated genera of all the subfamilies except the Ponerinæ, e. g., in Camponotus, some species of Pheidole, Solenopsis, Pogonomyrmex, Azteca, Dorylus, Eciton, etc. The term may also be employed to designate the intermediate forms between the small and large workers in such genera as Monomorium, Formica, etc.

(22) The **plerergate**, "replete", or "rotund," is a worker which in its callow stage has acquired the peculiar habit of distending the gaster with stored liquid food ("honey") till it becomes a large spherical sac and locomotion is rendered difficult or even impossible. This occurs in the honey ants (some North American species of Myrmecocystus, some Australian Melophorus and Camponotus, and in a less extreme form in certain species of Prenolepis and Plagiolepis).

(23) The **pterergate** is a worker or soldier with vestiges of wings on a thorax of the typical ergate or dinergate form, such as occurs in certain species of Myrmica and Cryptocerus.

(24) The **mermithergate** is an enlarged worker, produced by Mermis parasitism and often presenting dinergate characters in the thorax and minute ocelli in the head.

(25) The **phthisergate**, which corresponds to the phthisogyne and phthisaner, is a pupal worker which in its late larval or semipupal stage has been attacked and partially exhausted of its juices by an Orasema larva. It is characterized by extreme stenonoty, macrocephaly and microphthalmy, and is unable to pass on to the imaginal stage. It is in reality an infra-ergatoid form.

(26) The **gynandromorph** is an anomalous individual in which male and female characters are combined in a blended or more often in a mosaic manner.

(27) The **ergatandromorph** is an anomaly similar to the last but having worker instead of female characters combined with those of the male. (Wheeler, 1903.)

It is usually stated that the fertilization or non-fertilization of the egg of the social Hymenopteron determines whether it shall give rise to a male or female. And as the queen represents the

typical female form of the species, the problem of polymorphism is to account for the various worker forms, and those like the soldiers, pseudogynes and ergatoid females which are more or less intermediate between the worker and the queen. The ergatomorphic males are regarded as having inherited worker characters. Thus the problem of polymorphism centers in the development of the worker. It must suffice in this place to give the briefest possible statement of the views of the various authors who have endeavored to account for the development of this caste. These authors may be divided into three groups:

1. Those who believe, with Weismann, that the various castes are represented in the egg by corresponding units (determinants). Fertilization is then regarded as the stimulus which calls the female determinants into activity and meager feeding the stimulus which arouses the worker-producing determinants in the young larvæ arising from fertilized eggs. Such an explanation is obviously little more than a restatement, or "photograph" of the problem. It seeks to account for the adaptive characters of the worker forms through natural selection acting on fortuitous congenital variations.

2. Those who believe, with Herbert Spencer, that there is no such preformation of the various female castes, but that these are produced epigenetically by differences in the feeding of the larvæ. The workers simply arise from larvæ that are inadequately fed but are nevertheless able to pupate and hatch when only a part of their growth has been completed. This is not, like the preceding view, a restatement of the problem, since the modifications induced by inadequate feeding are conceived as somatic and not as germinal, but it fails to explain how the worker caste acquires its adaptive characters, unless this caste is supposed to reproduce with sufficient frequency to transmit acquired somatic modifications to the germ-plasm of the species.

3. A third group of investigators believes, with Emery, that the germ-plasm of the social Hymenopteron is indeed implicated in the phenomenon, not, however, as possessing separate sets of determinants, but as being in a labile or sensitive condition and therefore capable of being deflected along different developmental paths by differences in the trophic stimuli acting on the larva. According to Emery, "the peculiarities in which the workers differ from the corresponding sexual forms are, therefore, not innate or blastogenic, but acquired, that is somatogenic. Nor are they

transmitted as such, but in the form of a peculiarity of the germ-plasm that enables this substance to take different developmental paths during the ontogeny. Such a peculiarity of the germ may be compared with the hereditary predisposition to certain diseases, which like hereditary myopia develop only under certain conditions. The eye of the congenitally myopic individual is blastogenetically predisposed to short-sightedness, but only becomes short-sighted when the accommodation apparatus has been overtaxed by continual exertion. Myopia arises, like the peculiarities of the worker ants, as a somatic affection on a blastogenic foundation.

"With this assumption the problem of the development of workers seems to me to become more intelligible and to be brought a step nearer its solution. The peculiarities of the Hymenopteron workers are laid down in every female egg; those of the termite workers in every egg of either sex, but they can only manifest themselves in the presence of specific vital conditions. In the phylogeny of the various species of ants the worker peculiarities are not transmitted but merely the faculty of all fertilized eggs to be reared as a single or as several kinds of workers. The peculiar instinct of rearing workers is also transmitted since it must be exercised by the fertile females in establishing their colonies."

The views above cited show very clearly that authors have been impressed by very different aspects of the complicated phenomena of polymorphism, and that each has emphasized the aspect which seemed the most promising from the standpoint of the general evolutionary theory he happened to be defending. Escherich (1906) has recently called attention to two very different ways of envisaging the problem; one of these is physiological and ontogenetic, the other ethological and phylogenetic. As these furnish convenient headings under which to continue the discussion of the subject, I shall adopt them, and conclude with a third, the psychological aspect, which is certainly of sufficient importance to deserve consideration.

While the ontogeny of nearly all animals is a repetition or reproduction of the ontogeny of the parent, this is usually not the case in the social Hymenoptera, since the majority of their fertilized eggs do not give rise to queens but to more or less aberrant organisms, the workers. And as these do not, as a rule, reproduce, the whole phenomenon is calculated to arouse the interest of both the physiologist and the embryologist. The former, con-

centrating his attention on the reactions of the animal to the stimuli proceeding from its environment, is inclined to study its later stages as determined by the reactions to such stimuli, without regard to any internal or hereditary predetermination or disposition, while the embryologist seeks out the earliest moment at which the organism may be shown to deviate from the ontogenetic pattern of its parent. If this moment can be detected very early in the development he will be inclined to project the morphological differentiation back into the germ-plasm and to regard the efforts of the physiologist as relatively unimportant if not altogether futile. Now in his study of the social insects the embryologist is at a serious disadvantage, since he is unable to distinguish any prospective worker or queen characters in the eggs or even in the young larvæ. Compelled, therefore, to restrict his investigations to the older larvæ, whose development as mere processes of histogenesis and metamorphosis throws little or no light on the meaning of polymorphism, he is bound to abdicate and leave the physiologist in possession of the problem.

The physiologist in seeking to determine whether there is in the environment of the developing social Hymenopteron any normal stimulus that may account for the deviation towards the worker or queen type, can hardly overlook one of the most important of all stimuli, the food of the larva. At first sight this bids fair greatly to simplify the problem of polymorphism, for the mere size of the adult insect would seem to be attributable to the quantity, its morphological deviations to the quality of the food administered to it during its larval life. Closer examination of the subject, however, shows that larval alimentation among such highly specialized animals as the social insects, and especially in the honey-bees and ants, where the differences between the queens and workers are most salient, is a subject of considerable complexity. In the first place, it is evident that it is not the food administered that acts as a stimulus but the portion of it that is assimilated by the living tissues of the larva. In other words, the larva is not altogether a passive organism, compelled to utilize all the food that is forced upon it, but an active agent, at least to a certain extent, in determining its own development. And the physiologist might have difficulty in meeting the assertion that the larva utilizes only those portions of the proffered food which are most conducive to the specific predetermined trend of its development. In the second place,

while experiments on many organisms have shown that the quantity of assimilated food may produce great changes in size and stature, there is practically nothing to show that even very great differences in the quality of the food can bring about morphological differences of such magnitude as those which separate the queens and workers of many ants.

These more general considerations are reinforced by the following inferences from the known facts of larval feeding:

1. There seems to be no valid reason for supposing that the morphogeny of the queens among the social Hymenoptera depends on a particular diet, since with the possible exception of the honey and stingless bees, to be considered presently, they differ in no essential respect from the corresponding sexual phase of the solitary species. In both cases they are the normal females of the species and bear the same morphological relations to their males quite irrespective of the nature of their larval food. Hence, with the above mentioned exception, the question of the morphogenic value of the larval food may be restricted to the worker forms.

2. Observation shows that although the food administered to the larvæ of the various social insects is often very different in its nature, even in closely related species, the structure of the workers may be extremely uniform and exhibit only slight specific differences. Ant larvæ are fed with a great variety of substances. The quality of the food itself cannot, therefore, be supposed to have a morphogenic value. And even if we admit what seems to be very probable, namely, that a salivary secretion—possibly containing an enzyme—may be administered by some ants at least to their younger larvæ, the case against the morphogenic effects of qualitative feeding is not materially altered, as we see from the following considerations:

3. In incipient ant-colonies the queen mother takes no food often for as long a period as eight or nine months, and during all this time is compelled to feed her first brood of larvæ exclusively on the secretions of her salivary glands. This diet, which is purely qualitative, though very limited in quantity, produces only workers and these of an extremely small size (micrergates).

4. In the honey-bees, on the other hand, qualitative feeding, namely with a secretion, the so-called "royal jelly," which according to some authors (Schiemenz) is derived from the salivary glands, according to others (Planta) from the chylific stomach of

the nurses, does not produce workers but queens. In this case, however, the food is administered in considerable quantity, and is not provided by a single starving mother, as in the case of the ants, but by a host of vigorous and well-fed nurses. Although it has been taken for granted that the fertilized honey-bee becomes a queen as the result of this peculiar diet, the matter appears in a different light when it is considered in connection with von Ihering's recent observations on the stingless bees (Meliponidæ) of South America (1903). He has shown that in the species of Melipona the cells in which the males, queens, and workers are reared are all of the same size. These cells are provisioned with the same kind of food (honey and pollen) and an egg is laid in each of them. Thereupon they are sealed up, and although the larvæ are not fed from day to day as in the honey-bees, but like those of the solitary bees subsist on stored provisions, this uniform treatment nevertheless results in the production of three sharply differentiated castes. On hatching the queen Melipona has very small ovaries with immature eggs, but in the allied genus Trigona, the species of which differ from the Meliponæ in constructing large queen cells and in storing them with a greater quantity of honey and pollen, the queen hatches with her ovaries full of ripe eggs. These facts indicate that the large size of the queen cell and its greater store of provisions are merely adaptations for accelerating the development of the ovaries. Now on reverting to the honey-bee we may adopt a similar explanation for the feeding of the queen larva with a special secretion like the "royal jelly." As is well known, the queen honey-bee hatches in about sixteen days from the time the egg is laid, while the worker, though a smaller insect and possessing imperfect ovaries, requires four or five days longer to complete her development. That the special feeding of the queen larva is merely an adaptation for accelerating the development of the ovaries is also indicated by the fact that this insect is able to lay within ten days from the date of hatching. If this interpretation is correct the qualitative feeding of the queen larva is not primarily a morphogenic but a growth stimulus.

5. The grossly mechanical withdrawal by parasites like Orasema of food substances already assimilated by the larva, produces changes of the same kind as those which distinguish the worker ant from the queen, i. e., microcephaly, microphthalmy, stenonoty, and aptery. This case is of unusual interest

because the semipupa, after the detachment of the parasite, seems to undergo a kind of regeneration and produces a small but harmonious whole out of the depleted formative substances at its disposal. What is certainly a female or soldier semipupa takes on worker characters while the worker semipupa may be said to become infra-ergatoid as the result of the sudden loss of the formative substances. These observations indicate that the normal worker traits may be the result of starvation or withholding of food rather than of the administration of a particular diet.

6. The pseudogynes of Formica admit of a similar interpretation if it be true, as I am inclined to believe, that they arise from starved female larvæ. Here, too, the organism undergoes a kind of regeneration or regulation and assumes the worker aspect owing to a dearth of sufficient formative substances with which to complete the development as originally planned.

7. In the preceding cases the ants take on peculiar structural modifications as the result of tolerating parasites that bring about unusual perturbations in the trophic status of the colony. When ants themselves become parasitic on other ants a similar perturbation ensues, but in these cases the morphological effects are confined to the parasitic species and do not extend to their hosts. This must be attributed to the fact that the parasites live in affluence and are no longer required to take part in the arduous and exacting labors of the colony. Under such circumstances the inhibitory effects of nutricial castration* on the development of the ovaries of the workers are removed and there is a tendency for this caste to be replaced by egg-laying gynæcoid individuals or by ergatogynes, or for it to disappear completely. These effects are clearly visible in nearly all parasitic ants. In the European Harpegoxenus sublævis, for example, the only known females in

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* Nutricial castration (from nutrix, a nurse) as understood by Marchal, must be distinguished from alimentary castration (Emery, Le Polymorphisme, etc.), although both are responsible for the infertility of the worker. Through alimentary castration the development of the reproductive organs is inhibited in the larva and pupa, and this inhibition is maintained in the adult by the strong nursing instincts which prevent the workers from appropriating much of the food supply of the colony to their individual use. In many of the higher animals also (birds, mammals) reproduction is inhibited by the exercise of the nutricial function. A third method of inhibiting or destroying the reproductive function is known to occur in the "parasitic castration" of certain bees and wasps (Andrena, Polistes) by Strepsiptera (Stylops, Xenos, etc.) See Perez, Des Effets du Parasitisme des Stylops sur les Apiaires du Genre Andrena. Actes Soc. Linn. Bordeau, 1886, 40 pp. 2 pll. Westwood has also described a Strepsipteron (Myrmecolax nietneri) which in all probability produces this form of castration in certain Formicidae.

certain localities are gynæcoid workers. In the American Leptothorax emersoni, as I have shown (1903), gynæcoid workers and ergatogynes are unusually abundant while the true females seem to be on the verge of disappearing. Among the typical amazon ants (Polyergus rufescens) of Europe, ergatogynes are not uncommon. In Strongylognathus testaceus the worker caste seems to be dwindling, while in several permanently parasitic genera (Anergates, Wheeleriella, Epœcus, Epipheidole and Sympheidole) it has completely disappeared. Only one cause can be assigned to these remarkable effects—the abundance of food with which the parasites are provided by their hosts.

8. In the Ponerinæ and certain Myrmicinæ, like Pheidole, Pogonomyrmex and Aphænogaster, the larvæ are fed on pieces of insects or seeds, the exact assimilative value of which as food can neither be determined nor controlled by the nurses. And while they may perhaps regulate the quantity of food administered, it is more probable that this must fluctuate within limits so wide and indefinite as to fail altogether to account for the uniform and precise morphological results displayed by the personnel of the various colonies. Moreover, any accurate regulation of the food supply by the workers must be quite impossible in cases like that of the Pachycondyla larva bearing the commensal Metopina.

9. The dependence of the different castes of the social insects on the seasons may also be adduced as evidence of the direct effects of the food supply in producing workers and queens. The latter are reared only when the trophic condition of the colony is most favorable and this coincides with the summer months; in the great majority of species only workers and males are produced at other seasons. Here, too, the cause is to be sought in the deficient quantity of food rather than in its quality, which is, in all probability, the same throughout the year, especially in such ants as the fungus-growing Attii.

While these considerations tend to invalidate the supposition that qualitative feeding is responsible for the morphological peculiarities of the worker type, they are less equivocal in regard to the morphogenic effects of quantitative feeding. Indeed several of the observations above cited show very clearly that diminution in stature and, in pathological cases, even reversion to the worker form may be the direct effect of under-feeding. To the same cause we may confidently assign several of the atypical phases among ants, such as the micrergates, microgynes, and micraners, just

as we may regard the macrergates, macrogynes, and macraners as due to overfeeding. These are, of course, cases of nanism and giantism, variations in stature, not in form. Similiarly, all cases in which, as in certain species of Formica, Camponotus, Pheidole, etc., the workers or desmergates vary in size, must be regarded as the result of variable quantitative feeding in the larval stage. Here we are confronted with the same conditions as Weismann observed in prematurely pupating blow-flies and entomologists have noticed in many other insects. Such variations are of the fluctuating type and are therefore attributable to the direct effects of the environment. The soldier and worker, however, differ from the queen in the absence of certain characters, like the wings, wing-muscles, spermatheca, some of the ovarian tubules, etc., and the presence of other characters, like the peculiar shape of the head and mandibles. In these respects the sterile castes may be regarded as mutants, and Weismann's contention that such characters cannot be produced by external conditions, such as feeding, is in full accord with De Vries's hypothesis. His further contention, however, that they must therefore be produced by natural selection need not detain us, since it is daily becoming more and more evident that this is not a creative but an eliminative principle. It is certain that very plastic insects, like the ants, have developed a type of ontogeny which enables them not only to pupate at an extremely early period of larval life, but also to hatch and survive as useful though highly specialized members of the colony. It is conceivable that this precocious pupation may be directly responsible for the complete suppression of certain organs that require for their formation more substance than the underfed larva is able to accumulate. At the same time it must be admitted that a direct causal connection between underfeeding on the one hand and the ontogenetic loss or development of characters on the other, has not been satisfactorily established. The conditions in the termites which are often cited as furnishing proof of this connection, are even more complicated and obscure than those of the social Hymenoptera. While Grassi and Sandias (1893) and Silvestri (1901) agree with Spencer in regarding feeding as the direct cause of the production of the various castes, Herbst (1901) who has reviewed the work of the former authors, shows that their observations are by no means conclusive; and Heath (1902) makes the following statement in regard to his experiments on Californian termites: "For months I have fed a

large number of termite colonies of all ages, with or without royal pairs, on various kinds and amounts of food—proctodæal food dissected from the workers or in other cases from royal forms, stomodæal food from the same sources, sawdust to which different nutritious ingredients have been added—but in spite of all I cannot feel perfectly sure that I have influenced in any unusual way the growth of a single individual."

This rather unsatisfactory answer to the question as to whether quantity or quality of food or both, have an ergatogenic value, has led some investigators to seek a solution along more indirect lines. Thus O. Hertwig and Herbst suggest that the morphogenic stimulus may be furnished by some internal secretion of the reproductive organs. This, too, is possible, but owing to our very imperfect knowledge of the internal secretions, even in the higher animals, we are not in a position either to accept or reject this suggestion.

We may conclude, therefore, that while the conception of the worker type as the result of imperfect nutrition is supported by a considerable volume of evidence, we are still unable to understand how this result can take on so highly adaptive a character. Such a concise effect can hardly be due to manifold and fluctuating external causes like nutrition, but must proceed from some more deeply seated cause within the organism itself. Of course, the difficulty here encountered is by no means peculiar to polymorphism; it confronts us at every turn as the all-pervading enigma of living matter.

An intensive study of the structure and habits of ants must inevitably lead to a certain amount of speculation concerning the phylogenetic development of their colonies. That these insects have had communistic habits for ages is clearly indicated by the fact that all of the numerous existing species are eminently social. There can be little doubt, however, that they rose from forms with habits not unlike those we find today in some of the solitary wasps, such as the Bembecidæ, or in the remarkable South African bees of the genus Allodape. Unlike other solitary wasps, the females of Bembex may be said to be incipiently social, since a number of them choose a nesting site in common and, though each has her own burrow, cooperate with one another in driving away intruders. Bembex has also taken an important step in the direction of the social wasps not only in surviving the hatching of her larvæ, but also in visiting them from day to day for the purpose of providing them with fresh insect food.

At a very early period the ants and social wasps must have made a further advance when the mother insect succeeded in surviving till after her progeny had completed their development. This seems to have led naturally to a stage in which the young females remained with their mother and reared their progeny in the parental nest, thus constituting a colony of a number of similar females with a common and indiscriminate interest in the brood. This colony, after growing to a certain size, became unstable in the same way as any aggregate of like units, and must soon have shown a differentiation of its members into two classes, one of the individuals devoted to reproduction and another class devoted to alimentation and protection. In this division of labor only the latter class underwent important somatic modification and specialization, while the former retained its primitive and more generalized characters. It is more than probable, as I shall attempt to show in the sequel, that this differentiation was manifested in the sphere of instinct long before it assumed a morphological expression. The social wasps and the bumble-bees are still in this stage of sociogeny. The ants, however, have specialized and refined on these conditions till they have not only a single marked alimentative and protective caste without wings and lacking many other female characters, but in some species two distinct castes with a corresponding further division of labor. In the phylogeny as well as the ontogeny these characters appear as a result of nutricial castration.

If the foregoing considerations be granted the biogenetic law may be said to hold good in the sociogeny of the ants, for the actual ontogenetic development of their colonies conforms not only to the purely conjectural requirements of phylogeny but also to the stages represented by the various extant groups of social insects. It is clear that we cannot include the honey-bee among these groups, since this insect is demonstrably so aberrant that it is difficult to compare it with the other social insects.

Comparison of the different genera and sub-families of ants among themselves shows that some of them have retained a very primitive social organization, and with it a relatively incomplete polymorphism, whereas others have a much more highly developed social life and a greater differentiation of the castes. Such a comparison, coupled with a study of the natural relationships of the various genera as displayed in structure, suggests that the advance from generalized to highly specialized societies

did not follow a single upward course during the phylogeny, but occurred repeatedly and in different phyletic groups. And since the complications of polymorphism kept pace with those of social organizations, we may say that the differentiation of the originally single worker caste into dinergates, or soldiers, on the one hand, and micrergates, or small workers, on the other, has been several times repeated in remotely related genera. In some genera (Stenamma sens. str., Leptothorax) there are also indications of a lapsing of highly specialized into simpler conditions by a kind of social degeneration. In its extreme form this manifests itself as a suppression of castes and a consequent simplification of polymorphism. Beautiful illustrations of this statement are furnished by the parasitic species that have lost their worker caste. But there are also cases in which the queen caste has been suppressed and its functions usurped by workers (Leptogenys).

Not only have these greater changes been effected and fixed during the phylogenetic history of the Formicidæ, but also many subtler differences such as those of stature, coloration, pilosity and sculpture. And although such differences belong to the class of fluctuating variations and are usually supposed to have a greater ontogenetic than phylogenetic significance, they are undoubtedly of great antiquity and must therefore be regarded as more important than many of the minor morphological traits.

Emery was the first to call attention to a number of peculiar phylogenetic stages in the development of stature among ants. (1894). He found by comparison with the male, which is to be regarded as a relatively stable and conservative form, that the cospecific females and workers may vary in stature independently of each other. The following are the stages which he recognized and some additions of my own:

1. In the earliest phylogenetic condition, which is still preserved in the ants of the subfamily Ponerinæ and in certain Myrmicinæ (Pseudomyrma, Myrmecina, etc.), the workers are monomorphic and of about the same size as the males and females.

2. The worker becomes highly variable in stature, from large forms (dinergates, or maxima workers) resembling the female, through a series of intermediates (desmergates, or mediæ) to very small forms (minima workers, or micrergates). This condition obtains in the Dorylinæ, some Myrmicinæ (Pheidole, Pheidologeton, Atta), Camponotinæ (Camponotus) and Dolichoderinæ (Azteca).

3. The worker becomes dimorphic through the disappearance of the desmergates, so that the originally single variable caste is now represented by two, the soldier (dinergate) and worker proper. We find this condition in certain Myrmicinæ and Camponotinæ (Cryptocerus, Pheidole, Acanthomyrmex, Colobopsis, etc.)

4. The soldier of the preceding stage disappears completely, so that the worker caste again becomes monomorphic, but is represented by individuals very much smaller than the female. Such individuals are really micrergates. This condition is seen in certain Myrmicine genera, especially of the tribe Solenopsidii (Carebara, Erebomyrma, Diplomorium, most species of Solenopsis, etc.)

5. The worker form disappears completely leaving only the males and females to represent the species, which thus returns to the condition of sexual dimorphism seen in the great majority of insects and other Metazoa. This occurs in the parasitic ants of the genera Anergates, Wheeleriella, Epœcus, Sympheidole and Epipheidole.

6. In certain species the workers remain stationary while the female increases in size. This is indicated by the fact that the worker and male have approximately the same stature. Such conditions obtain in certain Myrmicinæ (Cremastogaster), Camponotinæ (Lasius, Prenolepis, Brachymyrmex, the North American species of Myrmecocystus), and Dolichoderinæ (Iridomyrmex, Dorymyrmex, Liometopum).

7. The worker caste remains stationary while the female diminishes in size till it may become even smaller than the large workers. This occurs in certain parasitic species of North America, like Aphænogaster tennesseensis among the Myrmicinæ, and among the Camponotinæ in the species of the Formica microgyna group (F. difficilis, nevadensis, impexa, dakotensis, nepticula).

8. The female phase disappears completely and is replaced by a fertile, or gynæcoid worker form. This occurs in certain Ponerine genera like Leptogenys (including the subgenus Lobopelta), and probably also in Diacamma and Champsomyrmex. The conditions in Acanthostichus and certain Cerapachyi (Parasyscia peringueyi) indicate that the dichthadiigynes of the Dorylinæ may have arisen from such gynæcoid workers instead of from winged queens.

9. The female shows a differentiation into two forms (*α* and *β* females) characterized by differences in the structure of the legs and antennæ, in pilosity and coloration (Lasius latipes), or in the length of the wings (macropterous and micropterous females of L. niger). The macrocephalic and microcephalic females of Camponotus abdominalis and confusus described by Emery (1896) may also be regarded as *α* and *β* forms. In this series, stages one to five represent changes in the worker caste while the female remains relatively stationary, whereas stages six to nine represent the converse conditions. Stages one to four probably succeeded one another in the order given, but stage five may have arisen either from the first or fourth. The sixth to ninth stages, must of course, be supposed to have developed independently of one another.

The stature differences described in the above paragraphs are in most if not all cases, highly adaptive. This is clearly seen in such forms as the Indo-African Carebara, the huge, deeply, colored females of which are more than a thousand times as large as the diminutive, yellow workers. This ant dwells in termite nests where it occupies chambers connected by means of tenuous galleries with the spacious apartments of its host. The termites constitute a supply of food so abundant and accessible that the workers are able to rear enormous males and females, while they themselves must preserve their diminutive stature in adaptation to their clandestine and thievish habits. Similar conditions are found in many species of the allied genus Solenopsis, which inhabit delicate galleries communicating with the nests of other ants on whose larvæ and pupæ they feed. In one species of this genus (S. geminata), however, which leads an independent life and feeds on miscellaneous insects and seeds, the worker caste is still highly polymorphic.

Another interesting case of adaptation in stature is seen in the ants of the Formica microgyna group. The females of these are temporarily parasitic in the nests of other Formicæ and are therefore relieved of the labor of digging nests for themselves and rearing their first brood of larvæ. On this account they need not store up large quantities of food, so that the nourishment which in nonparasitic species goes to produce a comparatively few large females may be applied to the production of a large number of small individuals. This latter condition is, indeed, necessary in parasitic species which are decimated by many

vicissitudes before they can establish themselves successfully among alien hosts. I have already emphasized the adaptive significance of the disappearance of the worker caste among permanently parasitic species like Anergates, Wheeleriella, etc.

There are several cases in which the worker and female differ greatly in color, pilosity or sculpture, and in such cases either caste may be conservative or aberrant according to ethological requirements. Thus in certain temporary parasites like Formica ciliata, oreas, crinita, dakotensis, and difficilis, the female is aberrant in one or more of the characters mentioned, while the cospecific worker retains the ancestral characters of the same caste in the closely allied forms of F. rufa. The same condition is seen in a very different ant, Aphænogaster tennesseensis, as the result of similar parasitic habits. In all of these species the females alone have developed myrmecophilous characters, like the long yellow hairs of F. ciliata, or the mimetic coloring of F. difficilis, which enable them to foist themselves on allied species and thus avoid the exhausting labor of excavating nests and rearing young, whereas the workers remain unmodified.

The foregoing observations indicate that in morphological characters the worker and female of the same species have advanced or digressed in their phylogeny, remained stationary or retrograded, independently of each other. The same peculiarity is also observable in species with distinct worker and soldier castes. It thus becomes impossible, even in closely related species of certain genera, like Pheidole, to predict the characters of the worker from a study of the cospecific soldier or vice versa. And while adaptive characters in stature, sculpture, pilosity and color must depend for their ontogenetic development on the nourishment of the larvæ, it is equally certain that they have been acquired and fixed during the phylogeny of the species. In other words, nourishment, temperature, and other environmental factors merely furnish the conditions for the attainment of characters predetermined by heredity. We are therefore compelled to agree with Weismann that the characters that enable us to differentiate the castes must be somehow represented in the egg. We may grant this however, without accepting his conception of representative units, a conception which has been so often refuted that it is unnecessary to reconsider it in this connection.

Having touched upon this broader problem of heredity it will be necessary to say something about the inheritance or non-inher-

itance of acquired characters, especially as Weismann and his followers regard the social insects as demonstrating the non-transmissibility of somatogenic traits. In establishing this view and the all-sufficiency of natural selection to which it leads, Weismann seems to me to have slurred over the facts. While he admits that the workers may lay eggs, and that these may produce male offspring capable of fertilizing females, he nevertheless insists that this is altogether too infrequent to influence the germ-plasm of the species. I venture to maintain, on the contrary that fertile workers occur much more frequently in all groups of social insects than has been generally supposed. As this fertility is merely a physiological state it has been overlooked. Marchal has shown how readily the workers of the social wasps assume this state, and the same is true of the honey-bees, especially of certain races like the Egyptians and Cyprians (Apis mellifica, fasciata and cypria). In the hives of these insects fertile workers are either always present or make their appearance within a few days after the removal of the queen. Among termites fertile soldiers have been observed by Grassi and Sandias and fertile workers by Silvestri. Among ants fertile, or gynæcoid, workers occur so frequently as to lead to the belief that they must be present in all populous colonies. Their presence is also attested by the production of considerable numbers of males in old and queenless communities. In artificial nests Wasmann, (1891), Miss Fielde (1905) and myself have found egg-laying workers in abundance.

Now as the males that develop from worker eggs are perfectly normal, and in all probability as capable of mating as those derived from the eggs of queens, we are bound to conclude, especially if we adopt the theory of heredity advocated by Weismann himself, that the characters of the mother (in this case the worker) may secure representation in the germ-plasm of the species. Weismann is hardly consistent in denying the probability of such representation, for when he is bent on elaborating the imaginary structure of the germ-plasm he makes this substance singularly retentive of alteration by amphimixis, but when he is looking for facts to support the all-sufficiency of natural selection the germ-plasm becomes remarkably difficult of modification by anything except this eliminative factor. Certainly the simplest and directest method of securing a representation of the worker characters in the germ-plasm would be to get them from the worker itself that has survived in the struggle for existence, rather than through

the action of natural selection on fortuitous constellations of determinants in the germ-plasm of the queen. If we grant the possibility of a periodical influx of worker germ-plasm into that of the species, the transmission of characters acquired by this caste is no more impossible than it is in other animals, and the social insects should no longer be cited as furnishing conclusive proof of Weismannism.

Plate has attempted to overcome the difficulties presented by the normal sterility of the worker by supposing that the distinguishing characters of this caste arose prior to its inability to reproduce. He recognizes the following stages in the phylogeny of the social insects.

"1. The presocial stage with but a single kind of male and female.

"2. The social stage with but a single kind of male and female. The peculiarities in nesting, caring for the brood, and other instincts were already developed during this stage.

"3. The social stage with one kind of male and two or several kinds of females, which were all fertile, but in consequence of the physiological division of labor became more and more different in the course of generations. The division of labor took place in such a manner that the sexual functions passed over primarily to a group A, while the construction of the nest, predatory expeditions and other duties devolved mainly on another group of individuals (B) which on that account used their reproductive organs less and less.

"4. The present stage with one kind of male, a fertile form of female, which arose from group A, and one or several kinds of sterile females, or workers (group B)."

Plate assumes that the differentiation into sterile and fertile forms did not take place till stage 3, and if I understand him correctly, not till after "the races had become differentiated morphologically." This view, as he admits, resembles Spencer's. The two views, in fact differ merely in degree, for the underlying contention is the same, namely that sterility is one of the most recently developed characters among the social insects. There can be little doubt, however, that the smaller adaptive characters, for example those of the females of certain Formicæ above mentioned, must have made their appearance in the fourth stage of Plate's scheme. The view which I have advocated differs from Plate's in admitting that even in this stage the workers are fertile

with sufficient frequency to maintain a representation of their characters in the germ-plasm of the species. Conclusive evidence of the presence or absence of such representation can be secured only by experimental breeding and especially by hybridizing the male offspring of workers of one species (a), with females of another (b) that has workers of a different character. Under these conditions some of the characters of (a) should make their appearance in (b).

In the foregoing discussion attention has been repeatedly called to adaptation as the insurmountable obstacle to our every endeavor to explain polymorphism in current physiological terms. Of course, this is by no means a peculiarity of polymorphism, for the same difficulty confronts us in every biological inquiry. As the type of polymorphism with which we are dealing has been developed by psychically highly endowed social insects, it cannot be adequately understood as a mere morphological and physiological manifestation apart from the study of instinct. This has been more or less distinctly perceived by nearly all writers on the subject. However various their explanations, Spencer, Weismann, Emery, Forel, Marchal, and Plate all resort to instinct. Emery, especially, has seen very clearly that a worker type with its peculiar and aberrant characteristics could not have been developed except in a living environment consisting of the fostering queen and workers which instinctively control the development of the young in so far as this depends on external factors. The worker caste may be regarded as a mutation comparable with some of De Vries's Œnothera mutations, but able to repeat and maintain itself for an indefinite series of generations in perfect symbiosis with its parent form, the queen, because, notwithstanding its relative infertility, it can be put to very important social use. Among ants this social use not only pervades the activities of the adult workers but extends even to the more inert larval stages. Thus the latter represent a rich and ever-fresh supply of food that can be devoured whenever a temporary famine overtakes the colony. In certain species, like the East Indian Œcophylla smaragdina and the South American Camponotus senex, the larvæ are put to a more humane use as spinning machines for constructing the silken nest inhabited by the colony. These examples also illustrate the purposive manner in which an organism can satisfy definite needs by taking advantage of ever-present opportunities and mechanisms.

In the lives of the social insects the threptic, or philoprogenitive instincts are of such transcendent importance that all the other instincts of the species, including, of course, those of alimentation and nest-building, become merely tributary or ancillary. In ants, especially, the instincts relating to the nurture of the young bear the aspect of a dominating obsession. The very strength and scope of these instincts, however, renders the insects more susceptible to the inroads of a host of guests, commensals and parasites. Besides the parasitic larvæ of Chalcidids, Lomechusini and Phorids there are many adult beetles and other insects on which the ants lavish as much or even more attention than they do on their own brood. And when the ants themselves become parasitic on other ants, it is always either for the sake of having their own brood nurtured, as in the temporarily and permanently parasitic forms, or for the purpose of securing the brood of another species, as in the slave-making, or dulotic species.

The philoprogenitive instincts arose and were highly developed among the solitary ancestral insects long before social life made its appearance. In fact, social life is itself merely an extension of these instincts to the adult offspring, and there can be no doubt that once developed it reacted rapidly and powerfully in perfecting these same instincts. It is not so much the fact that all the activities of the social insects converge towards and center in the reproduction of the species, for this is the case with all organisms, as the elaborate living environment developed for the nurture of the young, that gives these insects their unique position among the lower animals. A full analysis of the threptic activities would involve a study of the entire ethology of the social insects and cannot be undertaken at the present time. Nevertheless the bearing of these instincts on the subject of polymorphism can hardly be overestimated and deserves to be emphasized in this connection.

All writers agree in ascribing polymorphism to a physiological division of labor among originally similar organisms. This is tantamount to the assumption that the phylogenetic differentiation of the castes arose in the sphere of function before it manifested itself in structural peculiarities. Although this view implies that the female, or queen, was the source from which both the instincts and structures of the worker were derived, it has been obscured by an improper emphasis on the instincts of the honey-

bee, in which the female is clearly a degenerate organism, and on certain specialized instincts, supposed to belong exclusively to worker ants like those of the slave-makers (Polyergus, and Formica sanguinea). We have therefore to consider, first the instincts of the queen, and second, any evidence that may go to show that instinct-changes precede morphological differentiation in the phylogeny of the species.

It is evident that the social insects may be divided into two groups according to the instinct role of the queen. In one group, embracing the social wasps, bumble-bees, ants and termites, the female is the complete prototype of her sex. Even the queen of the slave-making ants manifests in the founding of her colonies all the threptic instincts once supposed to be the exclusive prerogative of the worker caste. These may be called the primary instincts. After the colony is established, however, and she no longer needs to manifest these instincts, she becomes a mere egg-laying machine and her instincts undergo a corresponding change and may now be designated as secondary. She thus passes through a gamut of instincts successively called into activity by a series of stimuli which in turn arise in a definite order from her changing social environment. The workers, however, are capable of repeating only a portion of the female gamut, the primary series. In gynæcoid individuals there is also a tendency to take up the secondary series, but in most workers this has been suppressed by countless generations of nutricial castration. The social insects of this type may be called **gynæcotelic,** to indicate that the female has preserved intact the full series of sexual attributes inherited from her solitary ancestors. In these the primary and secondary series were simultaneous or overlapped completely, in the gynæcotelic social insects they are extended over a longer period of time and overlap only in part, as social life permits the extension of the secondary long after the primary series has ceased to manifest itself. It will be seen that the division of labor which led to the special differentiation of like females into workers and queens is clearly foreshadowed in the consecutive differentiation of instincts in the individual queen. The second group of social insects is represented by the honey-bees and probably also by the stingless bees (Meliponidæ). In these only the secondary instincts are manifested in the queen, while the worker retains the primary series in full vigor and thus more clearly represents the ancestral female of the species. This type may there-

fore be called **ergatotelic.** The suppression of the primary instincts in the queen honey-bee was undoubtedly brought about by a change in the method of colony formation. When the habit of swarming superseded the establishment of colonies by solitary queens, as still practiced by the gynæcotelic insects, the primary instincts of the female lapsed into abeyance or became latent. This change took place so long ago that it has had time to express itself in the structure of the honey-bee as compared with the worker (shorter tongue and wings, feebler sting, degenerate structure of hind legs, etc.)

The first of the following examples which seem to indicate the occurrence of instinctive prior to morphological differentiation, shows at the same time how the ergatotelic type of the honey-bee may have arisen from the gynæcotelic type of the social wasps and bumble-bees.

1. The queens of certain species of Formica (F. rufa, exsectoides, etc.) are no longer able to establish colonies without the coöperation of workers. The common method of colony formation among these insects is by a process of swarming like that of the honey-bee; a certain portion of the colony emigrates and founds a new nest with one or more of the queens. When this method is impracticable the young queen seeks the assistance of an allied species of Formica (F. fusca), the workers of which are willing to take the place of her own species in rearing her brood. In F. rufa and exsectoides there is nothing in the stature or structure of the queen to indicate the presence of these parasitic instincts, but, in many of the allied species, like F. ciliata, dakotensis, microgyna, etc., the colonies of which are smaller and no longer swarm, or do so only to a very limited extent, the queens have become more dependent on the workers of other species and have developed mimetic characters or a dwarf stature to enable them to enter and exploit the colonies of alien Formicæ.

2. In many ants the callows, or just-hatched workers, confine themselves to caring for the larvæ and pupæ and do not exhibit the foraging instincts till a later period. But even the adult workers may perform a single duty in the colony for long periods of time, if not indefinitely. Thus Lubbock, (1894), and Viehmeyer (1904) have observed in certain Formica colonies that only certain individuals forage for the community. The latter has also noticed that certain individuals, indistinguishable morphologically from their sister workers, stand guard at the nest en-

trances. In other genera, like Camponotus, Atta, Pheidole, etc., with species that have desmergates, the morphological differentiation between foragers and guardians is still unsettled. It becomes completely established, however, in certain genera and species with the suppression of the desmergates. A remarkable example of division of labor without corresponding structural differentiation is seen also in the above mentioned Œcophylla, an ant which inhabits a nest of leaves sewn together with fine silk. According to the observations of Dodd (1902) and Doflein (1905), when the nest is torn apart the monomorphic workers separate into two companies, one of which stations itself on the outside, draws the separated leaves together and holds them in place with the claws and mandibles, while the other moves the spinning larvæ back and forth within the nest till the rent is repaired with silken tissue.

3. An interesting case is presented by the honey-ants (Myrmecocystus melliger and mexicanus.) All the workers of these species, though variable in size, are structurally alike. Among the callows, however, and quite independently of their stature, certain individuals take to storing liquid food, as I have found in my artificial nests of the latter species, and gradually, in the course of a month or six weeks, become repletes, or plerergates. Except for this physiological peculiarity, which slowly takes on a morphological expression, the plerergates and ordinary workers are indistinguishable. We must assume, therefore, that the desire to store food represents an instinct specialization peculiar to a portion of the callow workers. There can be no doubt that as our knowledge of the habits of ants progresses many other cases like the foregoing will be brought to light.

It may be maintained that in these cases physiological states must precede the manifestation of the instincts, and that these states, however inscrutable they may be, are to be conceived as structural differentiations. There is undoubtedly much to justify this point of view. The elaborate sequence of instincts in the queen ant, for example, is accompanied by a series of physiological changes so profound as to be macroscopical. After the loss of her wings, the wing muscles degenerate and the fat-body melts away to furnish nourishment for the ovaries, which, in the old queen, become enormously distended with eggs as the breeding season approaches. Such changes would seem to be amply sufficient to account for the changing instincts. I have found

that mere artificial deälation at once alters the instincts of the queen, probably through a stimulus analogous to that which leads to the atrophy of a muscle when its nerve is severed, and in the case under consideration leads to the degeneration of the wing-muscles and to changes in the ovaries. In the mermithergates and pseudogynes we also have peculiarities of behavior which are attributable to peculiar physiological states. Similarly, nutricial castration may be said to be a physiological state resembling that of hunger. We may conclude, therefore, that the worker, both in its ontogenetic and phylogenetic development, is through and through a hunger-form, inured to protracted fasting. Miss Fielde has shown (1904) that the workers of Camponotus americanus may live nearly nine months without food, which is as long as the much larger and more vigorous queens are known to fast while establishing their colonies. The larvæ of ants, too, are known to remain alive in the nests for months without growing. And even when food is abundant the workers appropriate very little of it to their individual maintenance, but distribute it freely among their sister workers, the brood and queen. It is not improbable, moreover, that the single instinct peculiar to workers, the instinct to leave the nest and forage, is the direct result of a chronic state of hunger.

THE HABITS OF INSECTS AS A FACTOR IN CLASSIFICATION.*

HERBERT OSBORN.

There is, I presume, at the present time a very general agreement among systematists that our systems of classification should represent something more than a convenient placing of groups in divisions in which they may be discovered by some key. Certainly all naturalists who look into the significance of relationship must wish to see their classification represent what they can discover in the way of natural affinity or the lines of derivation of the respective groups. It is also, I presume, a common if not universal experience that in every piece of systematic work there remains at the end some unsolved problem or some remnant of uncertain species that cannot be placed to the satisfaction of the worker. It is not my expectation that I can solve these perplexities in a short discussion of the criteria for taxonomic work, but it appears to me that we may secure some assistance and reach, perhaps, more satisfactory results if we bring to our assistance in this difficult field as many as possible of the factors which have been concerned in the differentiation of species, and, therefore, a recognition of the characters by which species and the larger taxonomic groups may be separated. Of these different factors the habits associated with the life of insects is one which should doubtless be given much greater attention than has been our practice in most of our systematic work. In large part, of course, this is due to the fact that we have been compelled to work with collected material of which we knew practically nothing as to environment or habit, or sometimes, even as to the more general ecologic conditions. Such data ought to be considered more and more an essential part of the basis of classification.

Insects doubtless serve as well as any of the great groups of animals for the illustration of any biological principle, and it is my belief that almost every important principle in biology may be studied and elucidated within the group. What is said here about insects may, therefore, in large part be applied to other

*Annual address delivered at the Chicago meeting, January 3, 1908. The address was illustrated and amplified by a series of lantern slides.

groups of animals, but I wish especially to speak of this group. No better audience for such a subject could be possible than one including so many who are devoting a large amount of valuable time and effort to the perplexing problems of insect classification.

Some twenty years ago our worthy president, Professor Comstock, published a remarkably suggestive paper on Evolution and Taxonomy in which he set forth in a masterly manner the idea that what we believe in evolution should be used as a basis in our taxonomic work, or that our systems of classification should show the lines of evolution of the various groups. Since then some papers have made good use of this general principle, but there are still many groups in which current classifications have largely ignored the principle or sadly distorted it in interpretation.

Perhaps if we agree on the principle we have used unfortunate methods in determining its application, and it is with the hope of showing possibly a little more clearly one of the helps in determining this point that I propose to discuss the habits of insects in connection with the possible aid they may give us in tracing the lines of evolution.

Primitive insects which we may conceive to have been largely terrestrial in habit have diverged along certain main pathways such as adaptation to aquatic life, underground existence, arboreal life, sedentary condition, parasitic habit, gall making habit, and a host of minor lines of special adaptation. To bring out their significance we may best review somewhat hurriedly some of these lines of divergence.

SUBTERRANEAN LIFE.

The tendency of insects to burrow underground is perhaps one of the more primitive lines of adaptation, as it may very easily be seen to come from their efforts at concealment, to escape enemies, to avoid light, or in arid regions to escape excessive heat, and in many groups as the simplest mode of pupation. From the more general form, however, we find in almost every order cases of especially adapted species or sometimes whole genera or families including varying degrees of adaptation to underground life. Mole crickets are the most perfectly adapted of the Orthoptera, but indications of the easy stages in this group are shown by crickets and stone crickets which are less perfectly fitted for such life. A group taking these features into account would evidently place the mole cricket as the extreme form in this line of adaptation.

Among Hemiptera we have numerous cases of subterranean adaptation, the most of the Cicadas, the root inhabiting Fulgoridæ, Cercopidæ, Membracidæ, and the highly specialized underground species of Aphids and the burrowing Cydnidæ showing a drift in this direction. The Cicadidæ are extremely specialized for such life, and the nymphal stages profoundly modified, showing a long ancestry of underground life. Among the Fulgorids, Membracids and the Cercopids it occurs in isolated forms and in these is in most cases of recent origin. Among the Aphids many species of Rhizobius, Pemphigus and Schizoneura show this adaptation, often greatly complicated with association with ants and by alternation of food plants or different root and leaf feeding forms. In every case, however, there is the best of evidence of the derivation of these root living forms from an ancestry that lived only above ground, and hence a clue to their systematic relationships is easily found.

The ant lion is a special case of adjustment and a striking contrast to the aquatic and terrestrial members of its order. In the construction of its pit-falls it shows a plan of underground life that differs strikingly from that of any other insect and is so distinct that it may be considered a good family character.

In Coleoptera the underground habit is distributed among many different families, but is especially characteristic of the Scarabæidæ in a large section of which the underground condition prevails for all but a short period of adult life. Here there is a very distinct and extreme adaptation both in the matter of food and adjustment to soil that fits them for this condition. Among the flies we have the burrowing larvæ of the crane flies and the Bibionidæ.

Among the butterflies and moths we have but little adaptation to underground life aside from the burrowing into the ground for the purpose of pupation, but cut worms and sod worms spend a considerable portion of their larval life in the soil, though feeding for the most part above ground. The bees, ants and wasps present us with a number of extreme forms of underground habit, but this is in many cases associated with community life. In fact community life seems very likely to have originated in nearly every case from the insects which had adapted themselves to this sort of existence. Some sort of protection such as cavities in the ground or in rocks or trees may have been an essential factor in the development of community life.

ADAPTATION TO AQUATIC LIFE.

The insects which live in the water show very distinct lines of divergence from the terrestrial habit and we can trace in a great many different groups the connection with the land inhabiting forms with very great certainty.

There is at present probably no question as to the general principle of the derivation of aquatic forms from those inhabiting the land, but the relations of the different groups and the particular lines of adaptation are open to further study. One feature that is perhaps sometimes overlooked is that the groups in which the aquatic habit is most perfectly established are those which have been for the longest time fitted for such existence, and therefore show less perfectly the connection with land inhabiting forms. The groups of dragon flies and May flies may both be looked upon as having established the aquatic habit at a very remote period, and as showing at present a very perfect adjustment in the larval stage for this mode of life. In both of these groups the larvæ are capable of aquatic respiration and have been provided with tracheal gills, adapted on different lines, so that they need not come to the surface in order to gain air. The development of these tracheal gills, however, must have been a matter of long evolution, but the fact that they are associated with a complete but modified tracheal system is evidence of their origin, subsequent to that of trachea.

In the mosquito, on the other hand, we have forms in which such a perfect aquatic respiration is not developed, the larvæ, in nearly all species, being obliged to make frequent trips to the surface of the water in order to acquire fresh supplies of air. And here, too, there is a distinct interchange of the contents of the tracheal tubes permitted by the open spiracles. A more specialized condition is shown in the buffalo gnats where there is a development of gill filaments capable of absorbing oxygen from the water and permitting strictly aquatic respiration without any recourse to the atmosphere. It has lately been shown, however, that tracheal tubes are present but become much reduced in these gill filaments so that there is every reason to assume that the aquatic respiration is of comparatively recent origin.

In the aquatic Hemiptera we have a series of families which show successive stages of adaptation to aquatic life, and we may trace by easy stages the passage from land or shore living forms to those which are most completely specialized for aquatic life.

The water striders which live entirely on the surface of the water have a rather special adaptation, but with the Naucoridæ we reach a group in which the aquatic life is well established. These insects have their form well fitted for swimming, but their respiration is dependent upon the atmosphere, and they must make frequent trips to the surface. Somewhat more specialized are the Belostomidæ in which the ability to remain under water is very perfectly developed, but without special gill structures for aquatic respiration. The Nepidæ go further in that they have long tubular structures which permit them to reach the surface of the water without bringing the body up to the surface. The water boatman and Corixa, though not more specialized in these features, show in some other respects a more perfect adaptation and are to be considered as among the most extreme of the aquatic groups. It seems to me apparent from such a series as this that the arrangement of groups should be made to correspond as closely as possible with the successive stages in specialization for the particular habitat which is present. That these insects are descended from strictly terrestrial forms seems certain, and that their various adaptations represent different degrees of perfection in adjustment to the new habitat will, I believe, fit in most perfectly with the comparative study of their structure. It is shown, perhaps, most decidedly in the condition of the antennæ and in the modifications of the legs in adaptation to swimming.

Most of the aquatic beetles appear to have but recent adaptation to this habit, as all are obliged to secure air from above water, and in most species a considerable ability to live outside the water is present. It is also quite certain that the aquatic habit has in this group been acquired independently in the different families.

With the evidence that may be accumulated in all the different orders of insects it seems certain that in every group of insects having aquatic habits we may confidently trace a derivation from terrestrial ancestors, and hence in arranging phylogenies we may consider that those less perfectly adapted are the more primitive and those most perfectly fitted for aquatic life are the most specialized. This will involve some radical changes from accepted and time honored systems of classification, but will, I believe, in every instance result in more rational and satisfactory groupings.

THE SEDENTARY HABIT.

Insects in many different groups show a tendency to become fixed for part or all of the life cycle, and in some cases they reach very extreme conditions in this direction. It is most pronounced in the group of Hemiptera, and in this group it shows a very complete series of gradations from the free forms to those which are most extremely sedentary. In the Psyllidæ for example there are some forms which show a tendency toward attachment during the larval stages, but in others this is modified into the gall infesting habit. In the white flies there is fixation during the larval and pupal stages with the free adult. In Aphids there are many species which attach themselves by the mouth parts and remain practically fixed for long periods. This is notably true of such species as the beechblight, alderblight, wooly aphis and others. Among the scale insects we have the most extreme condition, but there are gradations from such free forms as the mealy bugs and the Orthezias through the unarmored scales to such very extreme forms as the Diaspids. There can be no question, it seems to me, that these series show the lines of divergence and that the more extreme attached species must have descended from those which had greater freedom, and that the sedentary habit has in this group become more and more fixed.

Some of the moths show a considerable tendency to fixation, and examples such as the case bearers and bag worms and the tussock moths show steps in the direction of fixation for certain portions of their existence.

COMMUNITY LIFE.

The community life in insects is another very striking line of adaptation and one in which we can see most positively the gradual derivation from the more primitive forms in which communal life is unknown. In its simplest condition it may be considered as represented in the aggregation of larvæ which remain and feed together for a considerable period, but in which there is nothing more than a mutual protection, construction of tents or other devices, and no development of distinct kinds of individuals as a result of social habit. We have, however, amongst the termites, the ants and the bees, extreme cases where the community habit resulted in a very striking production of different kinds of individuals in a colony, these being adapted to carrying on entirely different activities. While termites, ants and bees must be con-

sidered as having acquired the community habit independently, they have very distinct parallelism in the kinds of individuals which are produced. In all cases there are normal males and females and also a class of non-sexual individuals or neuters, but in both termites and ants these neuters have been further differentiated into forms which carry on different kinds of activities in the colony, as for instance workers and the soldiers. In some ants these duties are still further subdivided and give rise to most perplexing series of polymorphic forms.

Those of us who had the opportunity to hear Professor Wheeler's brilliant address a year ago will remember how remarkably these polymorphic forms have been developed and can appreciate also how essential a recognition of the functions and the lines of adaptation for these forms must be, in order that anything like rational arrangement of the species may be made.

Community life in birds, beaver, fur-seal, sheep, cattle and even in the human species has not by any means the extreme condition of specialization seen in some species of these insects that have been mentioned. Nowhere does it show anything like so profound a change in the economy, structure or the relations of the members in the community.

PROTECTIVE DEVICES.

In the way of special adaptation for protection, insects show a wonderful variety of forms and have been one of the favored groups for the illustration of this general practice in nature. We can illustrate it by the use of certain forms among our common species such as the gypsy moth which with its color and marking has become very perfectly adapted for protection on the bark of the birch which appears to have been its native food plant, as shown by Prof. C. H. Fernald at the Boston meeting. Our common luna moth probably illustrates this also, since its coloration is well adapted for protecting it among the leaves of its most common food plant. It appears also that the long tail of the hind wings may very likely assume the position of the petiole of the leaf, and therefore fit in very perfectly with the surroundings of the insect. I have been struck by this particular feature in seeing the moth resting in such a position as to simulate closely an attached leaf. Among the leaf hoppers there are a number of species which show a very complete adaptation in this direction. Nearly all of the species of Deltocephalus if noticed

in connection with the plants on which they are feeding will be found to have, both in color and shape, a most perfect protection in connection with the plants on which they are attached. In the little Lonatura there is not only a distinct similarity in the size and color of the small stems of its host plant, but there are short winged forms which fit in at certain seasons of the year still more perfectly with the food plant or the debris on the surface of the ground in which they may be collected. Driatura in the long and short winged forms appears at first sight to be rather conspicuous, but if taken in connection with the places where it lives is found to blend most perfectly with its surroundings and to be thereby very perfectly protected. Perhaps the most striking example among our native species is to be found in the genus Dorycephalus which lives upon the stems of large grasses, and in this form the head is very much elongated, the wings shortened, and the color so perfectly straw-like that upon the stem of the plant the insect becomes entirely invisible. The males are dark in color with longer wings, and probably rest more continuously on the darker portions of the dried leaves. A still further adaptation occurs with the young which collect in the heads of the plant and which resemble most perfectly the glumes of the seeds. So perfect is the adaptation in this form that none of the stages are readily found and it is only by beating the plants that they may be collected. A related species (D. vanduzei) occurring on smaller stemmed plants is perhaps even more distinctly specialized, the wings being more reduced and the body more elongate.

Another case which is especially striking is found in a small capsid which lives at the surface of the ground and which in the female is entirely wingless and the body so modified as to very perfectly resemble an ant. This resemblance does not stop with a superficial similarity, but may be noticed even in the basal segments of the abdomen which simulate in a striking manner the same segments in the abdomen of the ant. The male of this species is longed winged, very strikingly different from the female, and doubtless lives under quite different conditions, making use of its wings and flying readily from place to place.

Another quite striking case is to be found in the beach grasshopper which is common to sand dunes and beaches throughout a quite extended range of the United States. This species shows most perfect adaptation for protection on the surface of the sand, the spots and marking on the body blending so perfectly with the

color and form of sand grains that when at rest it is quite invisible. In the photograph shown the outline is indicated by shadows which were really necessary in order to make it apparent, but it may easily be seen, that without these it would be extremely difficult to discover the insect. Now none of these adaptations can be thought of as primitive but rather as highly specialized forms derived from an ancestry of more general habit. Ought this not to be recognized in their classification?

GALL MAKING INSECTS.

Another quite distinct line of divergence for insects is found in the gall making habit, a habit which involves not simply the action of the insect, but the stimulation by the insect of a certain plant activity that results in an abnormal growth which is of service to the insect either as a source of food material, or for protection, or both. That this adaptation occurs independently in many different groups of insects is clearly evident if we consider the distribution of the gall making groups. It is present even in the Acarina, species of which produce a very great variety of galls on many different plants. Among the true insects the aphides contain a considerable number of gall making species, and in some of these the galls are quite elaborate in structure. The Pemphiginae found on elms and poplars show very distinctly formed structures such as the poplar leaf gall. In the genus Phylloxera which is distinctly a gall making genus we have the common grape species and numerous species affecting the hickory, in all of which there is a very distinct gall for each species. The Psyllidae are distinctly gall making and the galls produced are very characteristic, and the whole life of the insect is adapted to this method of existence.

Among the beetles we have a number of gall making species, those of the genus Agrilus perhaps being the most distinctive, but it is evident that the gall making habit in this group is entirely independent of that in any other order, and even of any other family of the group of beetles. In the Diptera several families include gall making species, but the gnats are most distinctly developed in this direction. We have, however, every gradation in this family from species that are not gall makers up to those which produce the most perfect and constant forms, for example, the Hessian fly, willow galls and the grape filbert galls.

Of the Lepidoptera comparatively few gall makers are known, but amongst the tineids we find gradations from miners to gall makers.

Among the sawflies there are several genera which live entirely in galls and here again quite complete gradations may be observed from the more general mode of life to the distinctly gall making form. The most distinctly gall making group, the Cynipids, presents us also with almost every possible gradation from the simple attack on leaves to the formation of very elaborate gall structures, and by careful comparison of different forms we can trace with considerable sureness the lines of divergence for each of the species and their relative departure from primitive forms.

WOOD BORING INSECTS AND BARK BEETLES.

Of the insects that work into the substance of woody plants we have a considerable number, and many of them illustrate a long course of adaptation to this particular form of life. The termites show an extreme ability to tunnel into wood and devour the interior of large masses of woody structures, and for this purpose have the mouth parts considerably specialized. The habit, however, is associated with the community habit which is discussed under another head. Among the Lepidoptera we have several families in which this mode of life has been quite fully developed, the most striking forms being the Cossidæ including the large carpenter moths, the larvæ of which tunnel deeply into various hard wood trees, and the Sesiidæ, practically the entire family being specialized for this habit. It shows, however, considerable degrees of adaptation, the peach borer living mainly just beneath the bark in shallow cavities which may open to the surface, while in the Syringa borer, Currant borer and some others, the central portion of the stem or trunk of the tree is invaded. Among the beetles the family of long horned borers (Cerambycidæ) is among the most characteristic, and excepting a few forms such as the milk weed borers are adapted for penetrating deeply into very hard wood. The Hickory borer for example tunnels into the heart wood of Hickory, requiring a period of two or three years for its growth. The Locust borer, Poplar borer, and the familiar Apple borer are other well known examples. Again in the Buprestidæ we have a distinctly wood boring group, although in these the borers are usually confined to the younger wood or cavities beneath the bark. They show perhaps less

complete specialization for boring, but in the flattened form of young and adult show adaptation to the particular portion of the tree which they affect. The bark beetles present a somewhat different condition, but are no less distinctly specialized for their particular habitat. They live for the most part between the bark and hard wood and construct intricate tunnels sometimes of most peculiar pattern, and frequently occasion very great injury to the trees infested. The habit in these different groups has very evidently been reached by entirely independent routes and the lines of adaptation must be traced in each group separately. Often the particular steps of adaptation are very beautifully shown in the series of species which illustrate the divergence from external leaf eating forms to those which are most perfectly fitted for living within the plants.

Of the Hymentopera the horn-tail borers are the most distinctly specialized in this direction, and these show a derivation from the leaf feeding saw-fly forms. The ants and bees which burrow into wood or into the stems of plants show certain other forms in which the habit has been adopted by isolated small groups, but not adopted by the larger divisions.

THE PARASITIC PATHWAY.

In the direction of parasitic life some groups of insects have traveled very far and show almost as distinctly as any group of animals the effects of the parasitic life. So numerous are the examples in this line that we must select only a few of those which are most specialized or which illustrate most perfectly the lines of derivation for the habit. In the Mallophaga we have a group in which the parasitism is distinct for all the known species and in which the result of parasitism is shown in the entire absence of wings and in the very perfect adaptation of clasping organs in the feet. In their mouth parts and other structure, however, they show very perfectly their derivation from some psocid ancestor, and by selecting series of genera we can trace quite clearly the different steps in adjustment from forms which are but slightly parasitic to those which are most extremely dependent upon their attachment to a host. In some cases migration from one kind of animal to another is possible and probably frequent, but in other species more strikingly specialized there is a most rigid restriction to a single species and absolute dependence upon the association of individuals in that species for its distribution and survival.

The bot flies illustrate remarkably well the degrees of specialization in the parasitic life, the sheep bot which lives in the frontal sinus of the skull representing a much less important departure from a non-parasitic form than the horse bot which lives within the stomach and must be adapted not only to a special mode of nutrition but to a particular limitation in the matter of respiration, a feature which goes still further in the case of the ox bot with its circuitous route from egg through alimentary tract to its final resting place beneath the skin. We cannot conceive this latter form of adaptation except as a derivation from the more simple form of parasitism, and our classification in this group may well take this into consideration. A particularly extreme form of parasitism with the results of parasitic life is exhibited in the sheep tick and its allies where there has been not only a striking modification of the structures of the body, but a profound modification in its mode of development. In this it shows an extremity which is perhaps not exceeded by any other group of animals though paralleled by the parasitic Stylopidæ, and in every detail of which we must recognize the effect of the parasitic life. The other forms of parasitism such as the occupancy of the nest of bees by flies or other species of bees which occur in a bewildering number of intricate forms cannot be dwelt upon here. The remarkable adaptations of such parasitic forms as the Ichneumons and Chalcids in their adjustment to plant lice and scale insects, and the egg parasites in their extreme adjustment to the completion of a life cycle within the minute egg of some other species of insect, cannot fail to occur to all who have become at all familiar with the complexities of insect life.

I may perhaps be permitted to further illustrate this idea with one other example drawn from a group which has been one of my special studies. The Pediculidæ are, I will grant, a not very popular division of insects and yet in some of their adaptations and in the long course of parasitism which they seem to have undergone, they give us some of the most positive evidences as to the effects of the parasitic habit and also as to their course of evolution. We may readily appreciate their long adoption of the parasitic habit when we consider the wide divergence they show from other groups of insects, and the range of their hosts, and yet we must assume beyond question that their establishment as a parasitic group has been subsequent to the evolution of the group of mammals of which they are exclusively parasites.

I have elsewhere indicated my belief that the group originally came from some division of the Heteroptera and I am still skeptical concerning the recent attempts to relate them to Mallophaga, but for the present study this point is not essential. Granted a primitive form assuming the parasitic relation to some primitive mammal and we have the materials on which to construct a tentative phylogeny which we may test by such evidences from morphology, distribution and habit as may be available.

There are of course at least two plans on which we may account for the present distribution of the species of this family. One that the primitive parasitic form appeared at some time in the early history of the mammalian stem and that its subsequent history and the divergence of the various species has gone along parallel with the divergence of the host forms; the other that it appeared much later in history after the establishment of the mammalian groups and that from an establishment on some one group of animals it migrated to other mammals and the various species developed on new hosts by more recent evolution. The fact that most of the species have a single host to which they are restricted gives unusual opportunity to test any theory of evolution.

Confining ourselves to the Pediculidæ, although it would be interesting also to examine the relation of the Polyctenidæ occurring on bats, we have a group showing very clearly a common origin and possessing some very homogeneous characters, the most evident the single jointed rostrum and the single clawed tarsi. The separation of the genera has always seemed somewhat arbitrary and based as a matter of necessity in such simple forms on rather trivial characters, but some of these characters take on entirely new significance if correlated with the distribution of the genera with reference to their hosts.

It will be noticed from the diagram (Pl. II) that the groupings of these parasites bear a distinct relation to the main divisions of the class of Mammalia. While this is not presented as an accurate statement of the phylogeny of the mammals, nevertheless it represents the remoteness of some of these groups and illustrates something of the possible relationships between them. Assuming that the primitive parasitic group established itself on a primitive mammal, we can follow the divergence of the different groups with considerable assurance. There is a distinct type belonging to the group of rodents, another for the insectivora, another for

the ungulates, still another for the elephant, and a group covering the primates. Comparing these it appears that the ungulate and primate groups have really a closer relationship than either of these with the rodent forms, although in existing classifications the ungulate and rodent forms are embraced within the same genus. It appears to me more in accord with the facts, especially if we take into account this distribution and habit, to separate the rodent forms, and this will necessitate the forming of a new genus.

Clasping organs show distinct types for a number of these groups and quite varied forms in such apparently nearly related species as those affecting Horses, Hogs, Cattle, etc. The Insectivore type is extreme and introduces new features.

We have traced a few of the many lines of adaptation that have been followed by the groups of insects in their adjustment to the many and varied conditions of life; adjustments so numerous and so perfect that insects are today not only the most numerous in species but fitted to a greater range of conditions than any other class of animals. We certainly should take account of these different conditions in our systems of classification if we hope to have them represent the true relationships in nature. We should use the lines of divergence in habit to point the way to natural affinities. Distinct morphologic changes are almost invariably associated with adaptations, if indeed, they are not the direct response to these adaptations, and hence when habit, distribution, function and structure are read together, we should, if reading correctly most nearly approach the rational arrangement of groups.

I would not be understood as ignoring the fact that this principle has been recognized in the past. Such names as Phytophaga and Parasitica in Hymenoptera, Phytophaga, Mycetophaga, Hydrophilus, Gyrinus, Cryptophagus, etc., in Coleoptera, or such specific names as aquaticus, arborea, sub-terraneus, cavicola, etc., testify to due appreciation of habits by many systematic workers. But I wish to emphasize my belief that this principle may be used to advantage not only in tracing larger phylogenetic lines but in solving the perplexities of specific affinities among the minor taxonomic groups.

Students of animal behavior and psychology are beginning to associate the differentiation of groups with psychic characters, and such a claim as physiological species is not new even to ento-

mologists. It is evident that if systematists would keep their field of work abreast with the movements in other lines it will be necessary to take into account all the factors that may seem to give evidence as to affinity.

It should be clearly appreciated, however, and I think will be recognized by entomologists as quickly as any body of naturalists that habit is only one factor, that while it has had a determining influence in producing structure it has so frequently occurred in parallel lines in different groups that fundamental structures based doubtless on the more remote habit, must be taken into account. To ignore this would carry us back to such inconsistencies as placing whales with fishes, or the parasitic insects, fleas, lice, bird-lice, etc., in one group, Aptera. We must fully determine the significance of the deeper adaptations as revealed in more fundamental character along with the superficial modifications of more recent habit.

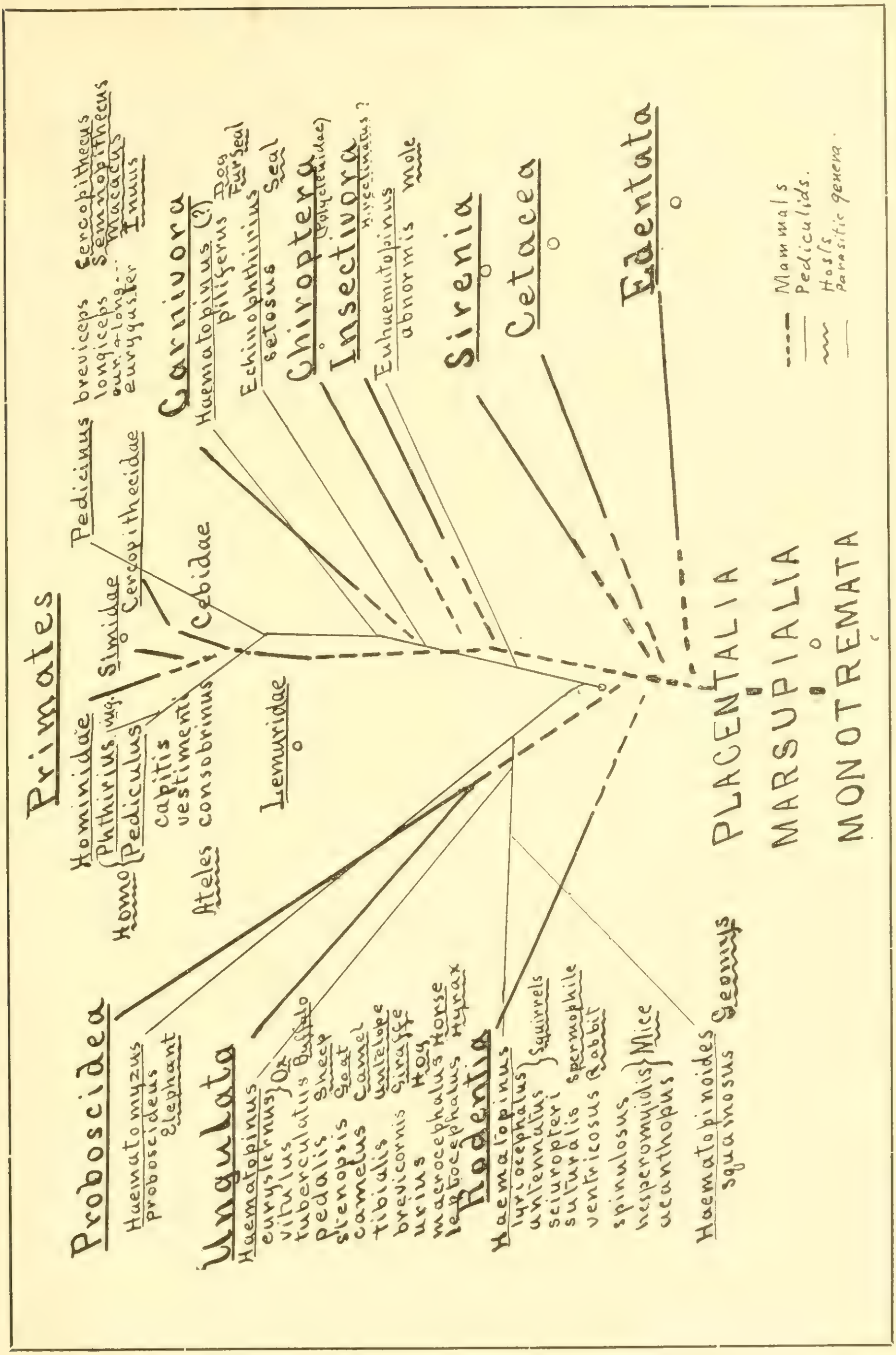

DIAGRAM ILLUSTRATING POSSIBLE LINES OF DIVERGENCE IN PHYLOGENY OF PEDICULIDAE.

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ANATOMICAL AND HISTOLOGICAL STUDIES OF THE FEMALE REPRODUCTIVE ORGANS OF THE AMERICAN SAW-FLY, CIMBEX AMERICANA, LEACH.

By Harry C. Severin and Henry H. P. Severin.

(with plates III to V.)

The material for the present paper was obtained in Milwaukee County, Wisconsin. The insects were collected during June and the early part of July usually from the peach-leaved willow (Salix amygdaloides Anders.) and the long-leaved willow (Salix longifolia Muhl.)

ANATOMICAL STRUCTURE OF THE FEMALE REPRODUCTIVE ORGANS.

The internal female reproductive organs of Cimbex occupy the greater part of the abdominal cavity. The paired ovaries, which embrace the dorso-lateral sides of the alimentary canal, are pale greenish in color and extend from the second to the posterior end of the seventh abdominal segment (Fig. 1, *ov*). Each ovary is made up of a large number of ovarian tubules arranged in a parallel manner. Anteriorly, these tubules taper gradually into the very fine thread-like terminal filaments, which are twisted together distally, thus holding the two ovaries together; posteriorly, the tubules of each ovary open into the funnel-shaped oviducts. The two oviducts unite in a forked manner below the alimentary canal to form the common oviduct or oviductus communis. In a dorsal view, the oviductus communis is almost entirely hidden by the spermatheca (Fig. 1, *sp*) and the large reservoir of the colleterial glands (Fig. 1, *cs*). The common oviduct terminates in the vaginal orifice, which is directly below the peculiar notch of the last sternite and the base of the ovipositor (Fig. 16, *vo*).

The spermatheca in the living condition is of a pale yellowish color, but in the material injected with 95 per cent. alcohol, it assumes a whitish color. From an external view, a constriction divides the seminal receptacle into two parts: (1) a more or less heart-shaped dorsal part (Fig. 1, *sp*); and (2) a funnel-shaped ventral portion, which opens into the dorsal wall of the common oviduct (Fig. 18, *f*). This boundary is further marked by two bundles of transverse muscles, which leave the spermatheca on either side and attach to the body wall. The musculature of the spermatheca and the function of these will appear in a subsequent paper.

In order to ascertain the exact course which the male intromittent organ takes during copulation, the abdomen of a number of specimens was cut in two during the sexual union and then dropped into 95 per cent. alcohol. If, after thorough dehydration, the abdomen of the male and female are separated, the opening in the female for the reception of the male organ can be distinctly seen to be directly beneath the peculiar notch of the last sternite (Fig. 16, *vo*). A careful dissection of the abdomen of two specimens obtained in this manner shows that the male copulatory organ passes not only into the common oviduct, but extends for some distance up into the funnel-shaped portion of the spermatheca.

The accessory glands consist of a mass of coiled tubes lying for the greater part dorsal and lateral to the colleterial sac and spermatheca. A dissection of an insect immediately after it has been killed, shows that the accessory sac and glands are filled with a rather thick translucent liquid. With the addition of alcohol this liquid hardens, forming a whitish solid. In Fig. 1, the accessory glands were teased away from the reservoir and receptaculum seminis. These glands, when they are spread apart, are found to be composed of a right and left mass of branching tubules, which terminate blindly in slightly swollen ends. The branching tubules composing these masses finally communicate with two long unbranched ducts, the right and left accessory gland ducts. These ducts, in turn, unite a short distance before joining the colleterial sac, forming a broad duct, the common colleterial gland duct, which communicates with the reservoir posteriorly (Figs. 17 and 18, *ccd*). The colleterial reservoir is a large slightly bilobed sac (Fig. 1, *cs*) which opens to the outside at the base of the saws by a broad, somewhat obliquely inclined duct (Figs.

13 and 18, *d*). Near the opening of the duct are two bundles of transverse muscles, which leave the dorsal wall of the duct and attach to the basal margin of the sheaths of the saws (Figs. 13 and 17, *tm*). Dorsally, the colleterial duct is in continuation with two lobes (Fig. 13, *dl*) which, in turn, are in continuation with the membrane that lines the inner surface of the saws. Ventrally, the wall of the duct terminates in a large fold (Figs. 13 and 18, *vf*). The duct of the colleterial sac thus opens out between the two dorsal lobes and the large ventral fold (Fig. 13, *d*).

When the spermatheca and colleterial sac are carefully pulled away from each other, there is revealed a triangular chitinous plate, which rests upon the dorsal wall of the oviductus communis. To this plate several bands of muscle attach (Fig. 13, *tp*).

HISTOLOGICAL STRUCTURE OF THE FEMALE REPRODUCTIVE ORGANS.

Ovaries: Each ovary is made up of a variable number of ovarian tubules or ovarioles, there being usually between twenty and thirty. In six specimens dissected, the number of ovarian tubes in the entire ovary was neither constant nor equal in either ovary, as is shown by the following figures:

Ovarioles in Right Ovary.	Left Ovary	Total in Both.
28	23	51
21	23	44
27	25	52
25	27	52
25	24	49
30	28	58
Average, 26	25	51

When the lowest egg in each tubule is ripe or nearly so, it is elongated more or less ovoid in shape with the distinction between dorsal and ventral surfaces indicated by a difference in curvature. After the lowest egg in each ovariole has passed out of the egg-tube, each tubule appears to be supported upon a stalk which opens into the oviduct. Alternating with each egg-chamber is a nutritive or yolk-compartment, the latter being distinguishable from the former with the naked eye only at the basal end of the ovarian tubule by its smaller size. The nutritive chamber, which is anterior to the basal egg, is usually smaller (Fig. 1, *nc*) than the one between the next two eggs. Towards the distal end of the ovariole, however, egg-chambers and yolk-chambers cannot be distinguished as such with the naked eye by a difference

in size. The tip of the egg-tube passes over gradually into the terminal chamber, which, in turn, passes over into the terminal filament.

A histological study of the wall of the egg-tube shows that it is covered externally by a peritoneal membrane, in which anastomosing, transversely-striated muscle fibres are embedded. Toward the distal end of the ovariole, the peritoneum is especially well developed, while posteriorly it gradually becomes thinner. The anastomosing muscles extend to the apex of the ovariole, being present in even the terminal filament. Within the peritoneum is a basement-like membrane; this membrane is sometimes distinctly visible between the nutritive and egg-chambers.

Oviduct and Oviductus Communis: In general, the histological structure of the oviduct will hold good also for the oviductus communis anterior to the spermatheca. The following layers, passing from within outward, are present: (1) a chitinous intima; (2) an epithelial layer; (3) a longitudinal muscle layer; (4) a circular muscle layer; and (5) a peritoneal membrane (Fig. 5).

When no eggs are present in the oviduct or oviductus communis, their wall is thrown into folds which are nearly filled with longitudinal muscles (Fig. 5, *lm*). The chitinous intima varies but little in thickness throughout the entire genital duct; such variations as occur are found directly beneath the egg-tubes, where the chitin is extremely thin and hardly perceptible. A surface view of this intima shows the presence of long, yellowish, chitinous bristles which are not distributed uniformly, but are clustered in groups (Figs. 3 and 5, *b*). The epithelial cells, with cell boundaries usually indiscernable, contain a large ovoid nucleus embedded in a slightly granular cytoplasm. External to the epithelial layer are the longitudinal muscles, which are somewhat better developed than the circular muscles just outside of these.

Spermatheca: A longitudnial section through the spermatheca shows that the structure of the chitinous intima is somewhat similar to the chitinous integument which Folsom (16) described for most insects. He writes: "The chitinous integument (Fig. 88) of most insects consists of two layers: (1) an outer layer, homogeneous, dense, without lamellae or pore canals, and being the seat of the cuticular colors; (2) an inner layer, 'thickly pierced with pore canals, and always in layers of different refractive indices and different stainability.' (Tower.) These two

layers, respectively *primary* and *secondary* cuticula, are radically different in chemical and physical properties." In the heart-shaped dorsal part of the spermatheca numerous pore canals, which stain deeply with gentian violet, penetrate the hyaline lamellated secondary layer of chitin in a more or less wavy manner (Figs. 4 and 7, *c*). They could, in some cases, be seen to enter the deeply staining primary layer, but could not be traced for any great distance here. In the funnel-shaped ventral portion of the spermatheca the pore canals could not be found.

A number of microscopic differences occur in the two divisions of the spermatheca. In the dorsal region of the heart-shaped part, the primary layer of chitin is smooth and entirely free from bristles (Fig. 7, *p*). At some distance dorsal to the constriction, which marks the boundary between the two divisions of the spermatheca, there are a few sharply pointed bristles scattered about irregularly (Fig. 4, *b*). Near this boundary the primary layer of chitin assumes a folded appearance with the bristles regularly arranged on one side of the fold and pointing ventrally (Fig. 4, *v*). At the constriction, however, the bristles change in direction and point dorsally and they are here arranged on the opposite side of the fold (Fig. 4, *a*). The bristles retain this position throughout the funnel-shaped ventral portion of the spermatheca.

In the dorsal heart-shaped region of the spermatheca the epithelium consists of prismatic cells, where cell boundaries are discernable, while in the funnel-shaped portion the inner ends of the cells vary somewhat in shape, owing to the folding of the chitinous intima. The cytoplasm in the dorsal and throughout the greater part of the ventral divisions of the spermatheca is granular towards the chitinous intima, but towards the basal end, the epithelial cells show a distinct longitudinal striation. Each cell contains an ovoid nucleus with its long axis at right angles to the chitinous intima (Fig. 7).

Near the region where the spermatheca opens into the common oviduct, the epithelial cells gradually become smaller and more or less flattened. The long axis of the ovoid nuclei usually assumes a direction parallel to the chitinous intima. The marked longitudinal striation has disappeared, and the cytoplasm is granular throughout these cells. Both primary and secondary layers of chitin are very much thinner, but the bristles are of the same size and still point dorsally (Fig. 2).

The transition from the spermatheca to the common oviduct is not difficult to determine, the chitin of the former losing its regularly folded appearance, and becoming more or less irregularly folded in the latter. The bristles, which in the spermatheca were regularly arranged on one side of the folds, do not have this uniform arrangement in the oviductus communis, but are clustered in groups (Fig. 3, *b*).

Accessory glands and sac: A study of sections cut through the accessory glands and ducts shows them to consist of the following layers, passing from within, outward: (1) a chitinous intima; (2) the so-called "endothelial or centro-tubular cells" of Fernard (15); (3) an epithelial layer; (4) a basement membrane; and (5) a peritoneal membrane.

Each cell of the accessory glands contains a so-called "vésicule sécrétante or vésicule intracellulaire" of Dierkx (13) or "vésicule radiée" of Henneguy (18). This vesicle is more or less oviform in shape and oftentimes strands of cytoplasm radiate from it (Fig. 9, *vr*). A small chitinous canal [canalicule intravésiculaire of Dierkx (13)] leaves the vesicle, follows a sinuous path to the chitinous intima, which it penetrates, and opens out into the lumen of the gland (Fig. 9, *c*). This canal, or its contents, stains with gentian violet and to a slight extent with haematoxylin. The nucleus is found in the basal half of the cell usually close to the vesicle.

The "endothelial or centro-tubular cells" are represented in Cimbex by nuclei, which are usually crowded against the chitinous intima (Fig. 9, *cn*) or wedged in between the inner ends of two glandular cells.

A comparison of a transverse section through the accessory glands with a similar section cut through the right or left colleterial gland duct or the common colleterial gland duct shows some marked differences. The sections show a different stainability, especially with the triple stain. The cytoplasm of the accessory gland cells stains deeply and the vesicle with its canal cannot usually be distinctly seen; in the ducts, however, the vesicle with its canal is well defined, the cytoplasm stains less deeply and shows a distinct longitudinal striation towards the basal end of the cells, but near the chitinous intima this striation is gradually lost and the cytoplasm becomes more homogenous (Fig. 10). In the accessory glands the large nucleus is spherical in shape and is found in the basal region of the cell, while in the ducts the more

or less ovoid nucleus varies in shape and may often be found between the vesicle and the outer boundary of the cell (Fig. 10) or nearer the central part of the cell. In the accessory glands the cell boundaries are very distinct (Fig. 9) but in the ducts these are indiscernable (Fig. 10). The cells of the glands are somewhat larger than those of the duct; the former surround a rather small central lumen, while the lumen of the duct is much larger.

The nuclei of the "endothelial or centrotubular cells," which are usually crowded up against the chitinous intima or wedged in between the inner ends of the two glandular cells in the accessory glands, are found midway in the epithelial layer in the ducts (Fig. 10, *en*). They can be distinguished easily from the nuclei of the epithelial cells by their smaller size.

All of these facts would tend to show that the cells of the right and left colleterial gland ducts, as well as the common colleterial gland duct, have either been emptied of their secretion, or that they have lost their power of secreting. As, however, quite a number of sections were cut through these ducts, and all showed the same structure we are inclined to believe that the cells have given up the secreting function and that the "endothelial or centro-tubular" nuclei have migrated from the position close up against the chitin to one between the cells. To definitely decide this point one would have to work probably with the pupae or larvae.

The histological change from the common colleterial gland duct to the accessory reservoir is rather abrupt. An outer, irregularly branching muscle layer makes its appearance upon the reservoir. The vesicles with their canals and the "endothelial or centro-tubular" nuclei gradually disappear in the sac (Figs. 8 and 11). A noticeable change in the epithelium is also apparent. In the common colleterial gland duct, the cytoplasm shows a distinct longitudinal striation toward the basal end of the cells, but near the chitinous intima the cytoplasm becomes granular; in the accessory sac, however, the cytoplasm is distinctly granular throughout the cell (Fig. 11). The epithelial cells of the colleterial reservoir vary in size, owing to the numerous, small, irregular folds into which the wall is thrown. Sharply pointed spines are present in the sac; these are especially numerous near the entrance of the common colleterial gland duct into the sac, and at the region where the latter passes over into its duct (Fig. 12, *sp*).

A series of transverse sections of the duct of the colleterial sac, shows the presence of a large ventral fold, which is partly filled with muscles and grooved at its middle (Figs. 14 and 15). The epithelial layer is somewhat better developed around this fold than at any other part of the duct. Around this fold the long axis of the ovoid nucleus is at right angles to the chitinous intima, but to either side of the fold, they gradually change their position and assume a direction more or less parallel to the intima (Figs. 14 and 15, *n*). The chitin lining the lumen is extremely thick. Near the opening of the duct are two bundles of transverse muscles which leave the chitinous intima and attach to the basal margin of the sheaths of the saws (Fig. 14, *tm*). These muscles when they contract, aided probably with the elasticity of the thick chitinous intima, close the duct.

A longitudinal section of this same duct shows that the muscles which, as already described from a cross section, partly fill up the large fold, can be traced over from the colleterial sac. Within the fold they spread out fan-like and attach to the chitinous intima (Fig. 12). These muscles when they contract open the duct.

A closer examination of the longitudinal section shows that the wall of the large ventral fold (Fig. 18, *vf*) when traced to the region where the duct opens out, bends upon itself and is continuous with the dorsal wall of the common oviduct. The chitinous intima of the large ventral fold decreases gradually in thickness toward the opening of the duct, and bending upon itself, continues as a layer of chitin of almost uniform thickness to the triangular chitinous plate. (Fig. 18, *chp*) which, as already described, rests upon the dorsal wall of the common oviduct between the spermatheca and colleterial sac. Projecting here and there from this chitinous intima near the opening of the duct of the sac, are long, yellowish bristles. Besides these bristles, large multinucleated glands with a pore canal penetrating the chitinous intima in their neighborhood and peculiar sense organs are scattered between the epithelial cells.

These sense organs project as papillae from the chitinous intima, and are very evident when the colleterial sac duct is mounted *in toto*. At the distal end of these papillae is a ring of chitin enclosing a circular opening. This ring of chitin stains with gentian violet. The papilla is in connection with a clear bladder-like structure, which is surrounded by a somewhat granular pro-

toplasm containing one or more nuclei. Within the clear bladder-like structure is a cone [Achsencylinders of Will (32)] which gradually becomes thicker toward its basal portion. From the basal region of the sense organ a nerve is given off.

The epithelium, when traced from the region where the duct of the colleterial sac opens out, to the triangular plate, is seen to be represented by cells which are somewhat wider than long, with their basal ends more or less rounded. Anterior to the triangular plate, however, there is an abrupt cellular change; the epithelial cells, as already mentioned in the description of the cellular change between the spermatheca and common oviduct, are extremely flattened and are represented chiefly by ovoid nuclei, which are arranged parallel to the chitinous intima (Fig. 3).

We are deeply indebted to Professor William S. Marshall for the use of literature taken from his excellent library.

Zoological Laboratory, Ohio State University.

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EXPLANATION OF PLATE III.

All figures except general dissections were drawn with a camera lucida.

FIG. 1. Dissection showing dorsal view of reproductive organs with left ovary removed: *ov*, ovary; *nc*, nutritive chamber; *od*, oviduct; *cod*, oviductus communis; *sp*, heart-shaped part of spermatheca; *acg*, accessory glands teased apart; *cs*, colleterial sac; *m*, muscle bundles of saw; *s*, sheaths of saw. (x4.)

FIG. 2. Longitudinal section of cells through the funnel-shaped portion of the spermatheca near the region where it opens into the common oviduct: *ep*, epithelium; *b*, bristle; *p*, primary layer of chitin; *s*, secondary layer of chitin. (x647).

FIG. 3. Longitudinal section of the dorsal part of common oviduct posterior to the entrance of the spermatheca: *ep*, epithelium; *ch*, chitinous intima; *b*, bristles. (x900.)

FIG. 4. Longitudinal section of the chitinous intima of the spermatheca, showing the change in direction of the bristles at *a*, near the constriction *e*, which divides the spermatheca into the heart-shaped dorsal portion and the funnel-shaped ventral part: *v*, bristle near the constriction and pointing ventrally; *d*, bristle below constriction and pointing dorsally; *b*, bristle dorsal to the constriction, these bristles being arranged irregularly upon the unfolded chitin; *p*, primary layer of chitin; *s*, secondary layer of chitin; *c*, pore canal. (x520).

FIG. 5. Cross section of a fold of the oviduct with the peritoneum not shown: *ch*, chitinous intima; *b*, bristles; *ep*, epithelium; *lm*, longitudinal muscles; *cm*, circular muscles. (x647).

FIG. 6. Longitudinal section of the cells of the colleterial sac: *n*, nucleus of epithelial cell; *ch*, chitinous intima. (x867.)

FIG. 7. Epithelium and chitinous intima of the dorsal region of the heart-shaped part of the spermatheca: *p*, primary layer of chitin; *s*, secondary layer of chitin; *c*, pore canal; *ls*, longitudinal striations of cytoplasm. (x647.)

Fig. 1.

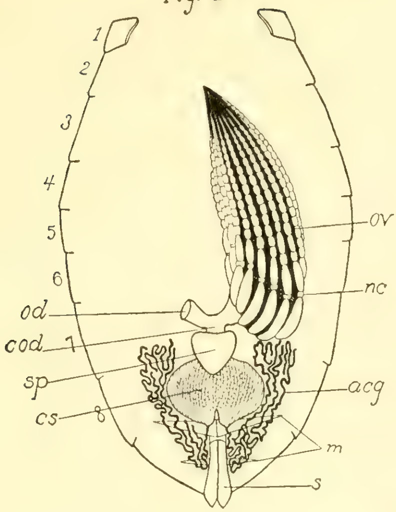


Fig. 2.

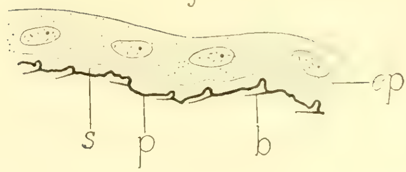


Fig. 3.

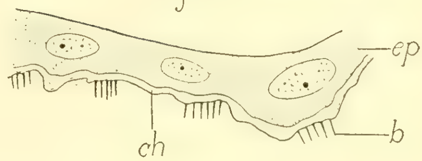


Fig. 4.

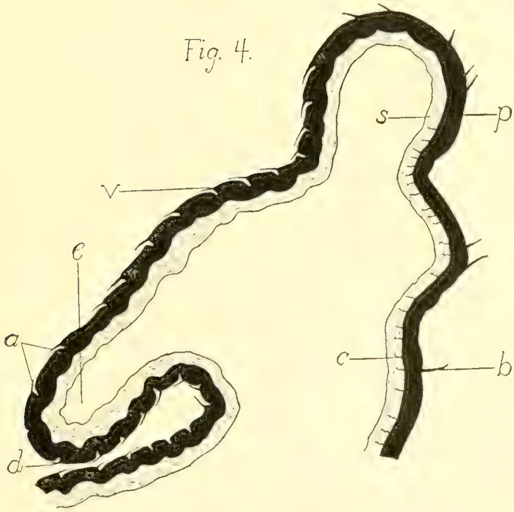


Fig. 5.

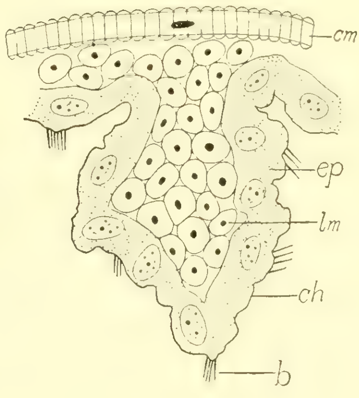


Fig. 7.

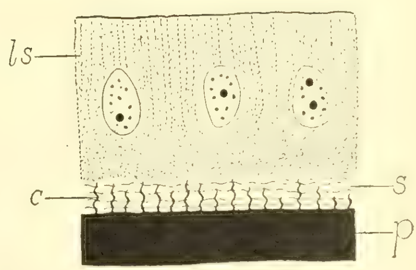


Fig. 6.

Severin.

EXPLANATION OF PLATE IV.

FIG. 8. Longitudinal section through the common colleterial gland duct and colleterial sac, showing the opening of the former into the latter: *o*, opening of the common colleterial gland duct into the colleterial sac; *sp*, spine; *en*, "endothelial or centro-tubular" nucleus; *n*, epithelial nucleus of the colleterial sac; *c*, canal of "vésicule radiée"; *vr*, "vésicule radiée", "vésicule sécrétante" or "vésicule intracellulaire". (x307.)

FIG. 9. Cross section of cells of the colleterial glands: *ch*, chitinous intima; *en*, "endothelial or centro-tubular" nuclei; *c*, canal of vesicule radiée; *vr*, "vésicule radiée", "vésicule sécrétante" or "vésicule intracellulaire". (x647.)

FIG. 10. Longitudinal section of cells of the common colleterial gland duct: *ch*, chitinous intima; *c*, canal of "vésicule radiée", *en*, "endothelial or centro-tubular" nucleus; *vr*, "vésicule radiée", "vésicule sécrétante" or "vésicule intracellulaire"; *ls*, longitudinal striations of cytoplasm; *g*, granular cytoplasm. (x900.)

FIG. 11. Longitudinal section showing the cellular change between the common colleterial gland duct and colleterial sac: *ch*, chitinous intima; *c*, canal of "vésicule radiée"; *en*, "endothelial or centro-tubular" nucleus; *vr*, "vésicule radiée", "vésicule sécrétante" or "vésicule intracellulaire"; *cp*, nucleus of epithelial cell; *ls*, longitudinal striations of cytoplasm; *g*, granular cytoplasm; *a*, transition of epithelium of duct to that of sac; *s*, spine; *m*, muscles. (x647.)

FIG. 12. Longitudinal section of the colleterial sac duct: *sc*, secretion; *sp*, spine; *ch*, chitinous intima; *m*, muscles of sac that pass into the ventral fold of duct and, spreading out fan-shape, attach to the chitinous intima. (x120.)

Fig. 8.

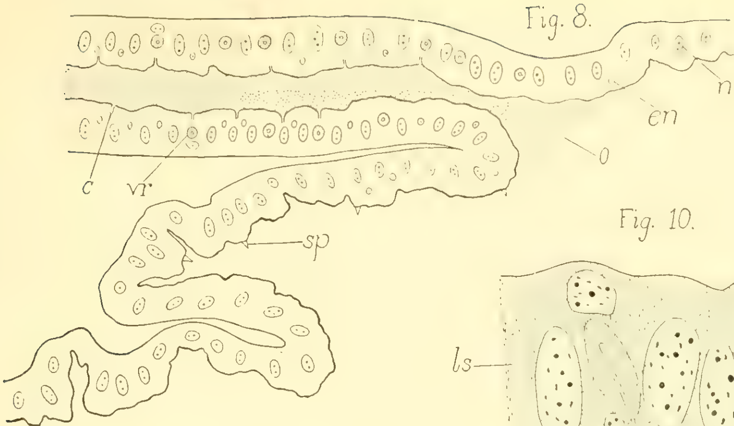


Fig. 10.

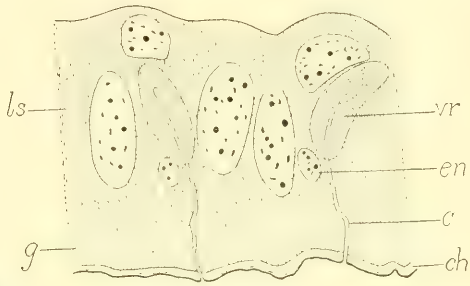


Fig. 9.

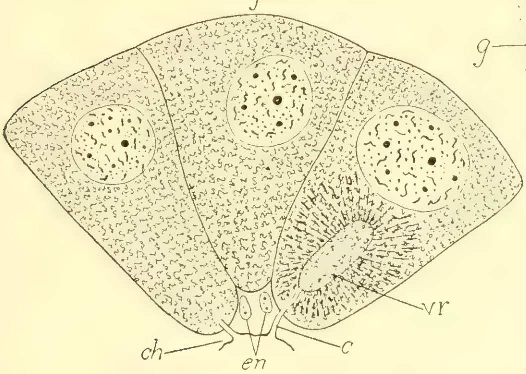
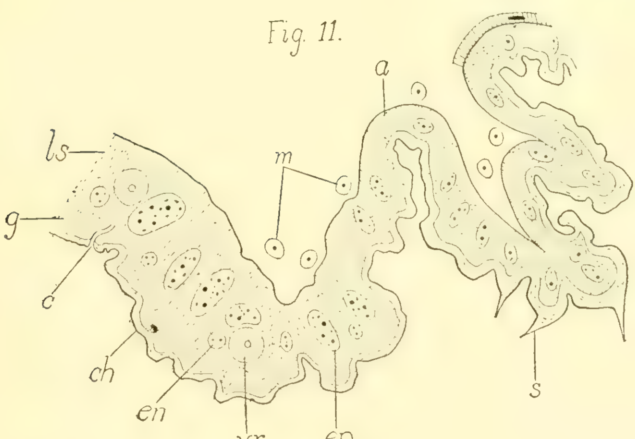


Fig. 12.

Fig. 11.



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EXPLANATION OF PLATE V.

FIG. 13. Ventral view of saws spread apart, showing the opening of the colleterial sac duct at *d*: *tp*, triangular chitinous plate to which bundles of muscles attach; *vf*, ventral fold; *dl*, lobes that are in continuation with the colleterial sac duct dorsally; *tm*, bundle of transverse muscles which leave the colleterial sac duct dorsally and attach to the basal margin of the sheaths of the saw; *ch*, chitinous intima of colleterial sac duct, to which the transverse muscle fibres attach; *t*, teeth of saw. (x12).

FIG. 14. Cross section of the colleterial sac duct near its opening, showing the attachment of some of the transverse muscles to the dorsal wall of the duct: *tm*, transverse muscle bundles; *n*, nucleus of epithelial cell; *ch*, chitinous intima. (x175.)

FIG. 15. Transverse section of colleterial sac duct nearer to the sac than figure 14, showing the ventral median-groove: *n*, nucleus of epithelial cell; *ch*, chitinous intima. (x175.)

FIG. 16. Last sternite showing the vaginal orifice, *vo*. (x6½.)

FIG. 17. Posterior view of colleterial sac: *cd*, colleterial gland duct; *ccd*, common colleterial gland duct; *o*, opening of common colleterial gland duct into the colleterial sac; *tm*, bundles of transverse muscles which leave the duct and attach to the basal margin of the sheaths of the saws; *l*, lobes that are in continuation with the colleterial sac duct dorsally.

FIG. 18. Diagram showing the common oviduct, spermatheca and colleterial sac with their openings: *cod*, common oviduct; *sp*, heart-shaped part of spermatheca; *f*, funnel-shaped part of spermatheca; *o*, opening of spermatheca into the dorsal wall of the common oviduct; *chp*, triangular chitinous plate; *cs*, colleterial sac; *ccd*, common colleterial gland duct opening into the colleterial sac; *d*, duct of colleterial sac, which opens between the saws; *s*, opening of common oviduct; arrows in the common oviduct indicate the path which the eggs take; the eggs thus pass beneath the opening of the spermatheca at *o*, and, after passing out of the vagina, are received by the saws at *s*. (x20.)

Fig. 13.

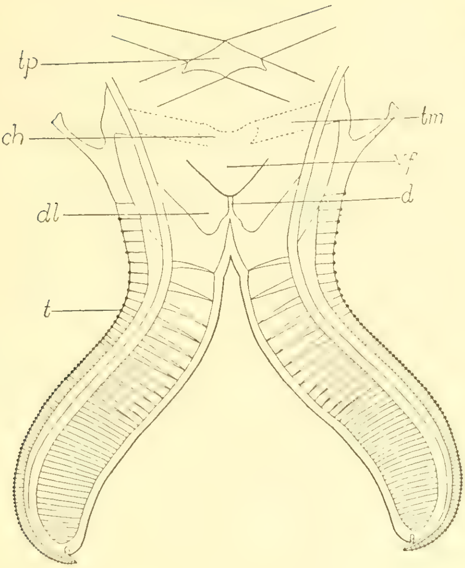


Fig 14

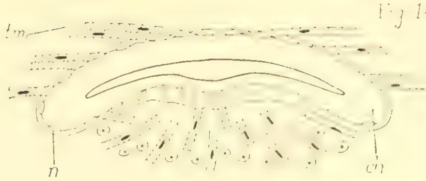


Fig. 15.

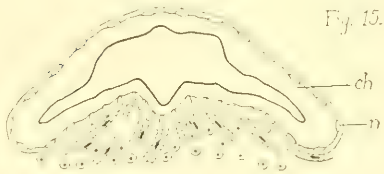


Fig 16

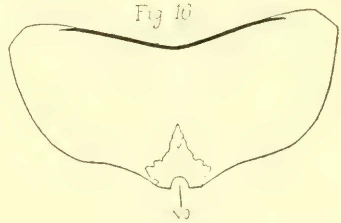


Fig. 18.

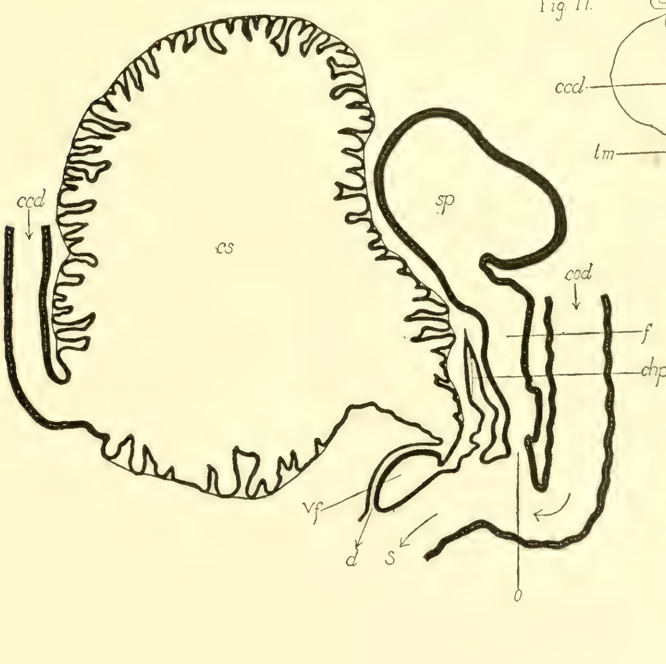
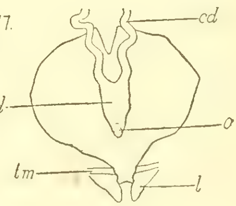


Fig. 17.



Severin.

SOME PROBLEMS IN NOMENCLATURE.*

By E. P. Felt.

Stability of nomenclature is greatly to be desired. It is, in our estimation, more important than that an investigator should have every particle of credit for discovering or recording the presence of a species, though the latter should not be ignored by any means. Certain peculiar questions in nomenclature exist in the Cecidomyiidae, a group in which we are much interested. It is hoped that this paper will provoke discussion and result in an agreement which will go far towards solving some vexatious questions. We desire at the outset to make this discussion absolutely impersonal, and for that reason the writer has taken the legal impersonal John Doe and some of his cousins to exemplify actual conditions or to illustrate situations which might arise. No significance should be attached to the dates employed, since they have no reference to real cases. Furthermore the names employed are *nomina nuda* and have no standing in nomenclature.

CASE 1.

1475. Cecidomyia floricola—Given by John Doe to yellowish Cecidomyiid larvae in unopened spiraea blossoms.

1478. Cecidomyia floricola, C. flavescens and Dasyneura abdominalis—All reared from the same blossoms by Edward Doe.

To what species did the larva observed by John Doe in 1475 belong? Can he, by any possibility, claim authorship to a species?

CASE 2.

1492. Cecidomyia gallicola—Described from the gall only, by John Doe.

1499. Cecidomyia gallicola—Adult reared and described by John Doe.

Does the species date back to 1492 and that name carry? We will suppose, for the sake of argument, that it does. Fortunately or unfortunately Richard Doe in 1575 discovered that Cecidomyia gallicola (John Doe 1499) is not the maker of the gall but an inquiline. He describes the maker of the gall as Lasioptera gallicola (John Doe 1492) and proposes for Cecidomyia gallicola (John Doe 1499) Cecidomyia alboscuta. Furthermore,

*Read at the Chicago meeting.

Edward Doe in 1575, though a few months later, reared still another species from this same gall. He likewise concludes that he has the true gall maker and describes it as Dasyneura gallicola (John Doe 1492). It happens that both the Lasioptera and the Dasyneura may produce this gall. Again we must ask the question: Can the gall carry the name? It is evident in this case that the systematic name, the one appearing in a catalogue listing the species of this family, is based and must of necessity be based on the characters presented by the adult. There are cases where two species belonging to the same genus may be bred from the same gall. Is there a Solomon present who can inform us which species shall bear the name earlier bestowed upon the gall? The situation is further complicated by the fact that it is very easy to rear Cecidomyiidae from some portion of a plant supposedly uninfested, as for example, apparently normal flowers, leaves or even stems.

CASE 3.

1496. Cecidomyia abstrusa—Gall described and the larva characterized by John Doe, so that it can possibly be referred to a genus.

1497. Lasioptera cincta—Collected at large and described by William Doe.

1499. Lasioptera abstrusa and L. splendens—Bred and described by Edward Doe.

Subsequent studies proved that both species may occur in about equal numbers in the gall. There are no characters given in the first description that can be relied upon to separate the larvae of the two forms. Was the species described in 1496, if so, what species? Furthermore, the adult described by Edward Doe as Lasioptera abstrusa in 1499, proves to be the same as the one William Doe collected and described in 1497.

There is little question as to what disposition should be made of case 1. A close examination of case 2 shows that ultimately the name must be carried by the adult. Would it not be in the interest of stability of nomenclature to accept the bestowal of the earlier names upon galls only in the spirit in which they were conferred; namely, as tentative pending the discovery and characterization of the imago? It is only a very little step farther to put in the same category, galls accompanied by a very brief description of the larva as illustrated in Case 3. We fully agree with the

suggestion that wherever possible the name bestowed upon the gall, should be given to the adult when reared therefrom. Unfortunately this is not always possible, since no one would for a moment allow that it was necessary to rear from a gall before describing the adult. It would be impossible and entirely impractical to attempt to enforce any such limitation, consequently sooner or later some decision must be made as to what constitutes a valid description in this group, as there are cases where species have been based on characters presented by the galls and subsequently the adults described. Despite the fact that we desire to be courteous to earlier workers and credit them with all due honor, nevertheless we must establish some standard in order to obtain a satisfactory working basis. The insistence that the true maker of the gall bear the same specific name as was originally bestowed upon the vegetable deformity it inhabits, will surely result in an almost unending series of unrivaled synonymical gymnastics, amusing though hardly edifying.

ON THE NERVOUS SYSTEM OF THE LARVA OF CORYDALIS CORNUTA L.*

By A. G. Hammar.

Owing to its large size and to the ease with which the parts may be dissected, the larva of Corydalis cornuta L. is especially favorable for the study of the nervous system. In spite of this fact, only fragmentary work has been done upon this species, and the present investigation was undertaken for the purpose of making a comprehensive study of the larval nervous system as well as for verifying the work already done.

Leidy '48 pictures and describes in a general way the nervous system of the adult insect, which in various respects differs from that of the larva. The only general discussion of the larval nervous system is that of Comstock and Kellogg '95. Though thoroughly accurate, this description is very concise, covering only the features of interest to the elementary student.

A detailed study of a limited region is that of Krauss '87, who confined his studies to the nervous system of the head of the larva. Although inaccurate in some details, his work is a valuable contribution to the knowledge of the nervous system and has been of much value to me in preparing this paper.

In 1895 an investigation was begun by Miss M. A. Nichols, for the purpose of determining the existence of a secondary nervous system such as that described by Newport '32 and '34. Unfortunately, this work was never finished, though promising interesting results. The notes and drawings were deposited in the entomological library of Cornell University, and in the study of certain features have been used to advantage by the writer.

For the material used, I am indebted to my friend, Mr. C. W. Palmer, of Westtown, Pa., who on different occasions has been kind enough to send me an abundant supply of living larvae from that locality. To Prof. J. H. Comstock I wish here to express my sincere acknowledgment for aid and encouragement liberally bestowed. For suggestions and aid received from members of the Entomological Staff of Cornell University, and most especially from Prof. W. A. Riley, under whose guidance this investigation has been carried on—I wish to express my sincere gratitude.

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* Contribution from the Entomological Laboratory of Cornell University.

METHODS.

The usual methods of dissection were employed in making the preliminary studies of the nervous system. On account of the transparency of the tissues, however, it was found necessary to supplement the examination of fresh specimens with the study of stained or fixed specimens in which the nerves were more clearly differentiated. For such preparations alcoholic picric acid solution has been used to very great advantage. It stains and hardens the tissues rapidly, so that the preparation can be used almost without delay. The specimens when immersed for a longer time (2 – 3 hours) in water will destain, but they can be restained any number of times desired.

Alcoholic sublimate (Gilson's fluid) is very effective in differentiating the tissues. It must, however, be borne in mind that sublimate is very corrosive to metals, and a black precipitate is quickly formed, when metal pins or tools are used.

In tracing certain nerves *intra vitem* staining with methylene blue has been used to advantage, but since the different nerves take up the stain very irregularly*, much time and patience has been required to secure satisfactory results. The living larva was injected with approximately 1–2 cc. of the solution (½% methylene blue in normal salt solution). Half an hour later it was etherized and opened along the back and then spread out on a sheet of cork, exposing the visceral cavity. The still living tissues were kept moist with the above solution until the desired results were obtained. It sometimes requires 3-5 hours before certain nerves take up the stain. Once stained they will retain it for only a short time. By the application of a few drops of hydrogen peroxide solution (H_2O_2) the stain is intensified.

It was found that for some features a process of maceration could be used to great advantage. By soaking for several days in water considerable amount of muscular tissue is loosened and can be washed off easily by moving the preparation in water, leaving the more resistent nerves exposed and distinct. Similar results were brought about by the use of 5-10% nitric acid solution. In either of these two processes, the preparation must be afterwards hardened in alcoholic picric acid. These methods should first be used after a general study of the nervous system has been made.

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* According to Ehrlich '86 (Biol. Centralb., VI, p. 214) the sensory nerves are the first stained, while the motor nerves require longer time.

INTRODUCTION.

The Corydalis larva, popularly known under the name of "dobson," "hellgrammite" or "crawler," is commonly found under stones at the bottom of swiftly flowing streams. Three years are required to complete the life cycle of the insect. The pupal and adult stages are of short duration, so that almost three years are required for the development of the larva.

This, when full grown, measures from 80 to 90 millimeters in length. It is rather oblong, depressed and tapering towards the posterior extremity. The entire body is dark brown or nearly black in color, with irregular markings on the chitinized portions of the head and thorax.

On either side of the head, caudad of the base of the antennae, there are six simple eyes. In very rare instances are there developed seven perfect eyes, the rudiments of the seventh being indicated by a light spot below the normal ones.

There are nine distinct abdominal segments, the last of which is provided with a pair of prolegs. The lateral borders of the first eight abdominal segments are pushed out into so-called lateral filaments. There is also a small pair of similar filaments to be found on the prolegs. On the ventral side of each of the first seven abdominal segments, there is a pair of large tracheal gills of a brush-like appearance. These are well supplied with tracheae, which ramify rapidly and send off branches, one to each separate thread-like portion of the gill.

As might be expected from the systematic position of the Corydalis, the nervous system of the larva is of a very generalized type. There is a ganglion for practically each segment of the body. Only in the last abdominal segments has there taken place a cephalization by the fusion of two or possibly three ganglia. The various ganglia of the central nervous system are connected longitudinally by two distinct nerve cords or connectives*, thus forming a chain, which extends on the ventral side throughout the length of the body. In the thorax and in the first abdominal segment, the ganglia are situated near the floor below the large ventral muscles, while the succeeding abdominal ganglia are all found above the same muscles.

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* In accordance with the suggestion of E. Yung '78, I have maintained the term *connectives* for the longitudinal nerve cords, while the term *commissure* has been used only for the transverse connections of symmetrical parts of the ganglia.

In the following consideration of the details of the larval nervous system I shall first take up the discussion of the central system, and follow this by a consideration of the so-called sympathetic system.

THE CENTRAL NERVOUS SYSTEM.

The Supraoesophageal Ganglia or Brain (Figs. 4 and 7, *b*, *b*). The so-called brain consists of two, large ovoid ganglia, situated dorsad of the oesophagus in the anterior portion of the head and immediately beneath the roof of the head, being protected only by a thin layer of connective tissue. The two ganglia are connected by a short, thick commissure, which in the drawing (Fig. 4) is indicated by the constriction between the two halves.

The dorsal portion of the anterior enlarged end of the aorta (Fig. 4, 7, *ao*) is attached to the caudo-ventral border of the brain.

In the brain of the Corydalis larva, the neuromeres—protocerebrum, deutocerebrum, tritocerebrum—are not so well differentiated as in the brain of Orthopterous insects studied by Viallanes **'87**, yet indications of the primitive ganglia constituting the brain are found in the form of basal enlargements of the optic, antennal, and the labral nerves which arise from the corresponding proto-, deuto-, and tritocerebrum. In the brain of the adult Corydalis, however, the neuromeres are more prominent than in the larva, the brain having undergone great modification during the pupal stage.

The optic nerves (Fig. 4 and 7, *o*, *o*). The lateral borders of the brain are pushed out into the optic nerve trunks. A short distance from their origin, each trunk divides into seven slender nerves, each of which supplies an ocellus. As already stated, the seventh ocellus is generally rudimentary. The seventh nerve corresponding to this eye, however, is always present.

The antennal nerve (Figs. 4, 5, and 7, *a.a.*) This arises from the side of the brain ventro-cephalad of the optic nerve-trunk. The antennal nerve breaks up into three branches, of which the anterior main branch innervates the antenna. The second branch innervates the muscles of the antenna, situated at the base of the same. The basal branch, a rather slender nerve, originates near the ganglia and extends dorso-laterad.

The clypeo-labral nerve (Figs. 4, and 7, *cl*). This together with the arched nerve (*ar*), originates as a single nerve trunk

from the base of the crus cerebri or more generally dorsad of the base of the crus cerebri. Under no circumstances could this nerve be considered as originating from the crus, since it is a well established fact that the nerve fibres of the labral nerve arise from the tritocerebrum.

At a distance of from one-half to one millimeter from its point of origin, the clypeo-labral nerve becomes separated from the arched nerve and projects cephalad into the clypeus and labrum, where it breaks up into six branches. The distribution of these is obvious from an examination of figure 4 and need not be discussed in detail. The relation of branch *3* to the sympathetic system is worthy of note.

In addition to the above described nerves of the supra-oesophageal ganglia there is to be found a pair of minute nerves which arise near the middle line of the caudal portion of the brain (Fig. 4.) These project dorso-caudad to the roof of the head.

The Crura Cerebri (Figs. 2, 5, 7, *cr*). The crura cerebri consists of two large nerve cords connecting the supra- and sub-oesophageal ganglia and with them forming the so-called oesophageal ring. Each crus originates from the ventro-lateral border of the brain, turns ventrad around the oesophagus and enters the dorso-lateral border of the suboesophageal ganglion.

The suboesophageal commissure *(Figs. 2 and 7, *s.c*). Connecting the lower portions of the crura cerebri, and forming a semicircle round the ventral part of the oesophagus is the so-called suboesophageal commissure. This commissure, usually overlooked, has been found in a number of widely separated insects (for summary see Kolbe **'93**, pp. 411–413). In the most frequently cited instances this commissure originates from the brain, although a position similar to that of the Corydalis is reported for Libellula, Dytiscus, Carabus, Phryganea and various other insects.

From the suboesophageal commissure there are two cephalad projecting nerves, which innervate the upper longitudinal labial muscles (Fig. 2, *lm*).

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* Various names have been applied to this commissure. Thus, Lienard '80 calls it: *Les connexions transversales des commissures oesophagiennes;* Kolbe '93 *Quercommissure* or *Schlundring;* Edward Burgess '80: *Cross-nerve* or *commissure between the two hemispheres;* while Packard '98 refers to it as *transverse commissure of the oesophageal ring.* Since these terms are applicable only in limited groups it is preferable to use the term *suboesophageal commissure.*

The Suboesophageal Ganglion (Figs. 2, 5, and 7, *s.g*). The suboesophageal ganglion is situated below the oesophagus in the anterior portion of the head. It is a rather large ovoid ganglion with its caudal portion terminating in the two connectives which pass back to the first thoracic ganglion.

From the suboesophageal ganglion there arise the following nerves:

The mandibular nerve (Figs. 4, 5, 6, and 7, *md*). The mandibular nerve arises as a large nerve trunk from the upper part of cephalo-lateral border of the suboesophageal ganglion. For a distance of a few millimeters it runs cephalad underneath the pharnyx, then it turns dorso-laterad until reaching the level of the optic and antennal nerves. Here it projects laterad, passing in front of the column-like apodeme (*ap*), where it divides into three branches.

Branch *1* bends caudad and innervates the large mandibular muscles. Branch *2* is quite short and slender, and connects the mandibular nerve with a minute ganglion (*g*). This ganglion has been observed in several specimens and probably forms a part of the sympathetic system. The third branch of the mandibular nerve has two prominent ramifications, of which the first, labeled *5*, enters the mandible while the second, marked *3*, runs laterad until approaching the outer condyle of the mandible, where it divides, sending off one anterior smaller branch to this part of the head and one larger caudal branch to the mandibular muscles.

Nerve *4* has not been found connected with the central nervous system. It and the ganglion (*g*) will be discussed under the sympathetic system.

The maxillary nerve (Figs. 4, 5, and 7, *mx*). The maxillary nerve arises from the cephalo-lateral border of the suboesophageal ganglion. It is a rather large nerve trunk, projecting cephalad for the distance of a few millimeters, after which it breaks up into four branches (Fig. 5 *mx.*) The most proximal of these branches consists of a small nerve extending laterad to the base of the maxilla. The three remaining branches all originate from the same level shortly cephaled of the first branch. The two branches of the fourth, and also the anterior branch of the third, enter the maxilla. The second branch terminates in the enlarged basal portion of this organ.

THE LABIAL NERVE (Figs. 5 and 7, *1*). The labial nerve arises slightly ventrad of the maxillary nerve. It runs forward into the labium, where it gives off several branches. The first of these has three sub-branches, of which the proximal one projects mesad and innervates the ventral muscles of the labium; the second terminates in numerous branches near the lateral base of the labium; and the third projects to the latero-distal portions of the submentum.

Branch *2** arises cephalad of branch *1*, and runs mesad of the main nerve. Its termination has not been located definitely. Branch *3* innervates the lateral portions between the submentum and the mentum. Branch *4* supplies the distal border of the labium and branch *5* enters the labial palpus.

THE GUSTATORY NERVES (Fig. 5, *gn*). Projecting cephalad from the anterior border of the suboesophageal ganglion are two thread-like nerves which have been called by Krauss '84 the *gustatory nerves*. They innervate the regions surrounding the opening of the salivary glands.

THE SALIVARY NERVES (Figs. 2, and 5, *sn*). The salivary nerves consist of two long thread-like nerves, arising shortly cephalad of the connectives from the caudo-lateral border of the ganglion. They project caudad, parallel to the connectives and enter the prothoracic cavity, where they turn laterad, branching off near the sides of the prothorax.

It is interesting to note that up to the present time the salivary glands of Corydalis have not been described. It was first through the tracing of the nerves and the determining of their homologies that I was lead to recognize the salivary duct, the so-called "*unknown nerves*" of Krauss '84.

THE VENTRAL NERVE of the suboesophageal ganglion (Fig. 5, *w*). Slightly caudad of the maxillary nerves there arise from either side of the ganglion a small much branched nerve, which innervates the regions below this ganglion. There is also a short branch given off to the salivary ducts.

THE MEDIAN NERVE (Fig. 5, *m. n*). The median nerve arising from the suboesophageal ganglion will be described under the sympathetic system.

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* Krauss, '84, figures this branch as innervating the salivary duct. (Fig. II, 7).

THE GANGLIA AND CONNECTIVES OF THE THORAX.

In the thorax (Figs. 1 and 2) there are three quite similar ganglia, which are the nerve-centers of the pro-, meso- and metathoracic segments respectively. These ganglia are situated near the floor, ventrad of the longitudinal-ventral muscles and caudad of the center of each respective segment. They are of relatively large size, circular in outline and decidedly depressed.

The first thoracic ganglion (*I*) is connected with the sub-oesophageal ganglion by two comparatively long connectives. On entering the prothorax they diverge as illustrated in Fig. 2.

The connectives of the two following segments are but half the length of those described above. They are also distinct from each other, enclosing between them the furcae (*f*) to which the ventral diagonal muscles of corresponding segments are attached.

THE NERVES OF THE FIRST THORACIC GANGLION (Fig. 1, 2, *I*). From either of the lateral borders of this ganglion there arise three nerve-trunks (*A*, *B*, *C*), the first and third of which are as large in diameter as the connectives. The anterior nerve trunk (*A*) extends laterad and breaks up into numerous branches which in Fig. 2 have been labeled: *a*, *1*, *2*, *3*; *b*, *1*, *2*, *3*, and *c*, *1*, *2*, *3*, *4*. The origin and direction of these nerves is evident from the illustrations and need not be described in detail. The second branch of *a* passes along the floor of the segment and innervates the neck. Branch *3* also follows the floor of the segment and extends to the caudal portion of the head. Nerve *b* supplies the latero-dorsal portions of the segment; branch *4* of nerve *c* runs cephalo-laterad, innervating the lateral portion of the neck.

Nerve *B* is relatively smaller than either *A* or *C*. It forks near its origin, giving the appearance of two distinct nerves. It innervates the ventral and lateral muscles.

Nerve *C*. The nerve of the leg consists of one large main trunk, which near its origin gives rise to a slender branch.

THE NERVES OF THE SECOND AND THIRD THORACIC GANGLIA (Fig. 2, *II*, *III*). The general distribution of the nerves of the above two ganglia is very much the same and therefore will be described together.

Nerve *A*, which in the larva is a rather small nerve, becomes in the adult quite enlarged and constitutes the *alar nerve*.

Nerve *B* resembles that of ganglion *I* except that it has an additional branch (*1*), which is analogous in appearance and distribution to "*a*" of nerve trunk *A* of the prothoracic ganglion.

Nerve *C*, as described under ganglion *I*, consists of two branches.

THE NERVES OF THE CONNECTIVES (Fig. 2, n_1c, n_2c, n_3c, n_4c). From the connectives of the thorax there arise four pairs of nerves of which the first two belong to the prothorax, the third to the mesothorax and the fourth to the metathorax. In their origin from the connectives, these nerves display quite a variation. The first pair may arise from the connectives either in the head or in the prothorax. The two nerves of a pair are not always directly opposite but may arise at different levels.

The nerves of the first pair arising from the connectives (n_1c) extend laterad for a short distance receiving branches from the transverse nerve of the sympathetic system. They then turn caudad between the large ventral muscles and terminate in the caudal regions of the prothorax.

The second pair (n_2c) arise from the connectives near the first thoracic ganglion. They extend laterad to the sides of the prothoracic segment.

The third (n_3c) pair of nerves originates slightly caudad of the middle from the connectives between ganglia *I* and *II*. They extend laterad, one on either side, and give rise to three branches, at the same level, 2-3 millimeters from the base of the main nerve. The first of these branches projects cephalad into the caudal regions of the prothorax; the second extends laterad passing under the large trachea and gives off at this point a slender branch which joins the tracheal nerve. As Fig. 2 shows, this tracheal nerve is connected with the transverse nerve of the sympathetic system; the third branch runs caudo-laterad and passes over the large trachea to the sides of the mesothoracic segment.

The fourth nerve (n_4c) originating between the meso- and the metathoracic ganglia, resembles the third and its branches have an analagous distribution and relation to the remainder of the nervous system.

THE ABDOMINAL GANGLIA* AND CONNECTIVES.

The abdominal ganglia consist of eight small ovoid nerve centers, situated below the alimentary canal and above the large ventral muscles. As a rule each ganglion is situated in the

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* The modification of the first and eighth abdominal ganglia will be described separately.

anterior region of its segment. From above, the ganglia and the proximal portions of their nerves are protected by the ventral diaphragm, the outline of which is indicated in Figs. 1, *d*, *d*, by dotted lines.

The connectives of the abdominal ganglia consist of two distinct cords connecting the successive ganglia. Those of the first and last ganglia are very short because of the cephalization in these regions. The cephalic ends of the connectives are generally closely approximated, while the middle and caudal portions are slightly spread apart, so that the minute median nerve of the sympathetic system becomes exposed between the two connectives. In the abdomen there are no nerves arising from the connectives, such as were found in the thorax.

The Nerves of the Abdominal Ganglia.

The nerves arising from the first seven ganglia are pretty nearly uniform both in number and distribution. Fig. 3, representing the right side of the third segment, illustrates the typical condition of the nerves of the abdominal region. From each ganglion two sets of nerves arise, one pair lateral and one pair ventral.

The lateral nerve (*l*) extends laterad over the ventral muscles. It gives rise to five branches, which generally extend caudo-laterad to the different parts of the corresponding segment. Branch *1* originates from the cephalic side, near the base of the main trunk. It is a very small nerve and can be detected only in well prepared specimens. The distal end of this branch unites with the transverse nerve (*tv. n.*) forming a single nerve, which extends laterad to the minute *tracheal* nerve* (*tr. n.*) Branch *2* consists of a large nerve originating from the caudal side, a few millimeters from the base of the main trunk. It extends caudo-laterad over the neighboring muscles (Fig. 1, m_1) and then turns ventrad and innervates the deep lying ventral muscles. Branch *3* arises shortly distad of branch *2*. It is a rather large nerve, passing latero-caudad over the ventral muscles. On reaching the outer border of these muscles, the nerve passes underneath a few muscle-fibers (Fig. 1, m_2 and Fig. 8, v_1 m_1) of the same

* Since the nerves of the *tracheal system* have not been considered in this paper, in may be necessary to state that such nerves have been observed lying closely connected with the trachea and in certain instances dividing in such a way as to supply each tracheal branch. The tracheal nerves are connected with both the central and the sympathetic systems.

group. Thus the nerve on passing to the upper portions of the body is protected and held away from the viscera. Branch *4*, like branch *3*, passes underneath the muscle-fibers of m_2, then below the larger lateral tracheal tube and innervates the lateral filament. Branch *5* consists of a small nerve which originates from the proximal part of branch *4*. It generally extends laterad, passing under the lateral muscle fibers of m_2 (Fig. 1) and extends to the lateral trachea, where it unites with the tracheal nerve described in connection with branch *1*.

In the seventh segment, branch *1* of the lateral nerve trunk may be absent. When present, it does not join the transverse nerve as is generally the case in the other segments, but terminates in the ventral diaphragm.

The ventral nerve trunk (*v*), originates from the ventral side of the ganglion and extends caudo-ventrad innervating various of the more ventral muscles. Branch *4* passes between the muscles and the body-wall and innervates the tracheal gills (Fig. 3, *op.*)

Because of its inconspicuous position this nerve has been very generally overlooked though it is probably to be found in other groups.

The First Abdominal Ganglion. Unlike the rest of the abdominal ganglia the first is situated below the ventral muscles. It may be located readily by the presence of the diagonal and transveres muscles, which pass dorsad of it (Fig. 1). The nerves of this ganglion are homologous to those of the following ganglia, although they show greater tendency to variation than the latter. Thus branches *1* and *2* may sometimes arise as a single nerve independent of the main lateral nerve. Moreover, branch *1* ramifies more freely than do its homologues of the following segments and it has not been observed to be connected with the transverse nerve, but seems to innervate certain ventral muscles.

The Eighth or Terminal Ganglion (Figs. 10, *G. 8.*) The terminal ganglion of the central nervous system has been pushed cephalad into the central portion or even to the anterior border of the seventh segment, taking the normal position of the seventh ganglion, which, also, has been forced cephalad, and is situated at the caudal border of the sixth segment. The seventh and eighth ganglia are united by two very short connectives, which are generally not longer than the diameter of the last ganglion.

From the large size of the terminal ganglion and because of the numerous nerves arising therefrom, it is evident that it is produced by the fusion of two or more ganglia. Oudemans '87 determined in Machilis maritima Latr. that the last abdominal ganglion originated by the fusion of the last three ganglia. On its dorsal side there remained parts of two transverse nerves, which indicated the boundaries of the original ganglia. Such rudiments of the transverse nerves have not been found in the terminal ganglion of the Corydalis larva. Influenced, however, by the fact that there are four pairs of nerves arising from this ganglion, we may conclude that these correspond to two lateral and two ventral pairs of nerves of two abdominal ganglia. Although it may be possible to homologize some of these nerves with those of previous ganglia, it cannot be considered conclusive that the last ganglion is produced by the fusion of but two ganglia, since it may be possible that the nerves corresponding to a third have disappeared. An investigation of the embryological condition would be the only way to settle this problem.

Notwithstanding the cephalic displacement of the eighth ganglion, all of its nerves innervate the eighth and terminal segments. As stated above, there are four pairs of nerves arising from this ganglion (Fig. 10 *a*, *b*, *c*, *d*). The first of these originates from the lateral border of the ganglion and runs caudo-laterad to various parts of the eighth segment. The branches of this nerve can readily be homologized with the lateral nerve of previous ganglia. Branch *1*, as in some of the previous ganglia, is in this case absent altogether. Branch *2* passes over the large ventral muscle bundle m_3 in the eighth segment and innervates the ventral muscles. Branch *3* supplies the dorsal parts of the segment; branch *4* enters the lateral filament; branch *5* joins the tracheal nerve.

Nerve *b* is homologous with nerve *v* of the previous segment. It originates from the mid-ventral portion of the ganglion and extends caudad, passing underneath the ventral muscles (m_3), then turning laterad, innervating approximately the same regions as the ventral nerve of previous ganglia.

Very probably nerves *c* and *d* are homologous to the lateral (*l*) and ventral (*v*) nerve trunks of ganglion *7*. Nerve *c* has three prominent branches, the first of which forks giving off one nerve to the lateral filament and one to the proleg. Branch *2* enters the proleg. Branch *3* innervates the reproductive organs as

shown in Fig. 10, passing through the lateral borders of the seminal vesicle.

THE INTESTINAL NERVE* (Figs. 9 and 10, *in. n*). The intestinal nerves consist of a pair of long, thread-like nerves, which arise from the proximal ends of nerve *c* of the terminal ganglion. They extend cephalad to the second abdominal segment, where they are attached to the sides of the small intestine, shortly caudal of the origin of the Malpighian tubes.

Each proximal portion of these nerves gives rise to five caudad-projecting branches, four of which innervate the hind intestine. The first branch arises from the very base of the intestinal nerve and lies dorsad of nerve *c*. It divides into three sub-branches before reaching the hind intestine. Branches *2*, *3*, and *4* do not ramify until reaching the intestine. Branch *5* is comparatively small and, unlike the four previous ones, does not reach the intestine, but is attached to a mass of adipose tissue (*ad*).

The intestinal nerves represent the first or basal branch of the lateral nerve, but in distribution they differ radically from that of this branch in preceding segments. It is probable that the suppression of the respiratory nerve, originally occurring between the ganglia represented, and the in-pushing of the proctodaeum are sufficient to account for these modifications, great as they appear.

THE SYMPATHETIC NERVOUS SYSTEM.

The sympathetic system is divided into the UPPER SYMPATHETIC SYSTEM, lying above the alimentary canal, and the LOWER SYMPATHETIC SYSTEM, lying below it.

The nerves and ganglia of this system are very minute and constitute a supplementary system intimately connected with the central system. Most of the nerves are susceptible to methylene-blue and can best be studied in specimens prepared with this stain.

The UPPER SYMPATHETIC SYSTEM is confined to the anterior dorsal portion of the alimentary canal and most particularly to the pharynx and oesophagus within the head. It can be divided into an UNPAIRED MEDIAN and a PAIRED LATERAL SYSTEM.

THE UNPAIRED MEDIAN, STOMOGASTRIC, or, as it is more generally termed, the VAGUS SYSTEM, consists of the following parts:

* Comstock & Kellogg, '04, p. 49.

THE ARCHED NERVE (Fig. 4 and 7, *ar*). The arched nerves connect the vagus system with the central system. They arise in connection with the clypeo-labral nerves, one from each upper basal portion of the crus cerebri, and bend mesad so as to meet in the frontal ganglion.

THE FRONTAL GANGLION (*fg*). This ganglion consists of a very minute nerve center, situated a short distance in front of the supraoesophageal ganglia, with which it is connected by an exceedingly fine nerve strand. (Fig. 7, *i*).

THE FRONTAL NERVE (Figs. 4, 7, *f*). The frontal nerve arises from the anterior border of the frontal ganglion and extends cephalad into the clypeus, where it bifurcates.

THE PHARYNGEAL NERVE (Figs. 4, 7, *pn*). From either side of the frontal ganglion there arises a small nerve, undescribed by former workers. It extends latero-ventrad, to the lower portions of the pharynx. The term *pharyngeal* may be applied to this nerve.

THE RECURRENT NERVE* (Figs. 4, 7, *r.*). The recurrent nerve consists of a single median nerve-cord arising from the caudal border of the frontal ganglion. It extends back passing under the supraoesophageal ganglia, and between the aorta and oesophagus, to terminate in the vagus ganglion (*v*).

THE VAGUS GANGLION (Figs. 4, 7, *u.*) This is a minute elongated ganglion, not much wider than the diameter of the recurrent nerve. It is situated 3-4 millimeters caudad of the supraoesophageal ganglion, between the aorta and the oesophagus, and constitutes the termination of the recurrent nerve.

THE STOMOGASTRIC NERVES (Figs. 4 and 7, *st.*) consist of two parallel cords, arising from the caudal border of the vagus ganglion. At the point of emergence from underneath the aorta, they diverge, passing over to either side of the oesophagus, whence they continue caudad, innervating the alimentary canal and terminating in the neighborhood of the mid-intestine.

THE LATERAL OR PAIRED SYMPATHETIC SYSTEM (Figs. 4 and 7). This system is characterized by a pair of small ganglia (*lg*), situated one on either side of the oesophagus and slightly caudad of the pharyngeal constriction. The nerves are quite minute and are confined to the dorsal and lateral portions of the anterior region of the oesophagus.

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* According to Berlese '07, p. 597, the recurrent nerve is typically double and appears as a single nerve through coalescence.

There seems to be no connection between the two lateral ganglia, nor are these connected with the vagus system as is generally the rule in insects. They are united to the central nervous system by the nerves *u* and *m*. Nerves *u* are attached to the ventral borders of the two halves of the brain and run caudad one on either side of the recurrent nerve until emerging from underneath the aorta to which they are closely joined. At this point, the nerve *u* increases in thickness (*z*) and curving gradually latero-ventrad, finally enters the cephalic portions of the ganglion. Nerve *m* is attached to the ventro-lateral border of the brain and extends caudad along the dorso-lateral portion of the oesophagus. Near its attachment to the brain, it gives off a lateral branch (*x*), which appears like a separate nerve of the brain. Caudad, nerve *m* gives off three branches, the first two of which join the enlarged transverse portion of nerve *u* (labeled *z*). The third branch joins nerve *p* of the same system. Nerve *p*, extending cephalad as a continuation of nerve *z*, innervates the lateral parts of the pharynx, caudad of the crura cerebri. Nerve *q* arises from the anterior lateral part of the ganglion (*lg*) and extends cephalad, passing between the mandibular muscles and the oesophagus, and underneath the optic, antennal and mandibular nerves to the lateral portions of the mouth. Nerve *s* projects caudad from the lateral ganglion, passing for some distance parallel to the stomogastric nerves. It gives off numerous small branches to the sides of the oesophagus.

THE VENTRAL SYMPATHETIC OR SUPERADDED SYSTEM (Figs. 1, 2, 3, 5, and 10).

The ventral sympathetic system consists of a minute MEDIAN NERVE (*mn.*) extending caudad from each of the first eleven ventral ganglia. As a rule, the median nerve gives rise to a pair of lateral branches, the TRANSVERSE OR RESPIRATORY NERVES (*tv. n.*) which extend laterad over of the connectives and nerves of the central system.

The median nerve arising from the suboesophageal ganglion is comparatively short. In a few instances it has been found wanting altogether, so that the transverse nerves arise directly from the ganglion. These transverse nerves are united with the first pair of nerves of the connectives (n_1c).

In the thorax, the median nerves are short and give rise to relatively very large transverse nerves. These extend caudo-lateral over the ventral muscles and unite with the tracheal

nerves (Fig. 2, *tr.* n.) Each transverse nerve of the third thoracic ganglion gives off a small mesal branch, which innervates the small transverse muscles of this region. Before reaching the tracheal nerve, the last mentioned transverse nerve receives branch *5* of the lateral nerve trunk of the first abdominal ganglion.

As a rule, the median nerve of each abdominal segment extends caudad to the anterior border of the following ganglion (Fig. 3). Here it terminates in an enlargement, which may be the GANGLION OF THE MEDIAN NERVE* (*mg*).

The transverse nerves are two in number for each median nerve. Each extends laterad receiving branch *1* of the lateral nerve and forming with it a single nerve, which connects with the tracheal nerve.

Exceptions to the above typical condition occur in the first and seventh abdominal segments. The median nerve of the former does not give rise to any transverse nerves (Fig. 1) and in the latter the median nerve does not reach the following ganglion but terminates in the two transverse nerves (Fig. 10).

As stated in connection with the mandibular nerve, a minute ganglion is to be found at the base of the mandible, (Fig. 6), forming a part of the sympathetic system. The main nerve *4* enters the mandible and gives off four branches. The caudal termination of nerve *4* has not been traced. Nerves *6* and *7* are also part of this system. Branch *2* connects the ganglion with the central system.

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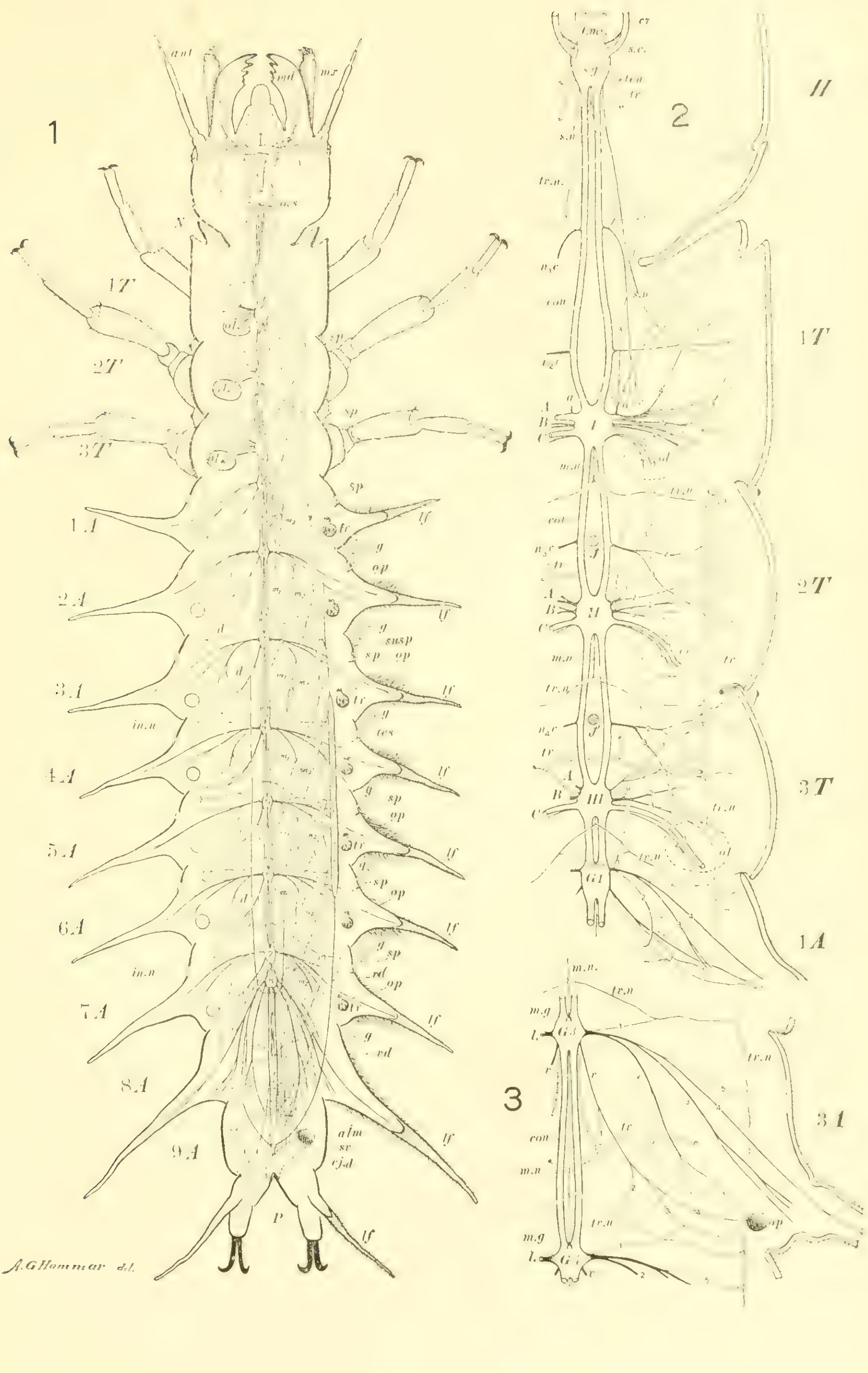
EXPLANATION OF PLATES.

FIG. 1. Dorsal aspect of the larva, showing the entire nervous system. The ventral longitudinal muscles have been represented on the right side to illustrate their relation to the nerves.

1A, *2A*, *3A*, etc., abdominal segments.
1T, *2T*, *3T*. first, second and third thoracic segments.
I, *II*, *III*. first, second and third thoracic ganglia.
1-8. first to eight abdominal ganglia.
alm. alimentary canal.
ant. antenna.
d, *d*, *d*. outline of the ventral diaphragm.
ej. d. ejaculatory duct.
g, *g*. tracheal gills.
in. n. intestinal nerve.
lf, *lf*. lateral filaments of the abdominal segments.
m_1, m_2. upper-great-ventral-recti-muscles.
m_3. large bundle of muscles in the ninth abdominal segment.
md. mandible.
mx. maxilla.
N. neck.


1
2
3
A. G. Hammar del.

oes. oesophagus.
ol. opening to the leg.
om. oblique muscles of the first abdominal segment.
op. opening to the tracheal gills.
P. prolegs.
sp. spiracle.
susp. suspensory ligament of the testis.
s. v. seminal vesicle.
tes. testes.
tr. tracheae supplying the gills.
vd. vas deferens.

FIG. 2. Dorsal view of the five anterior ventral ganglia. Lettering as in Figs. 1 and 3.

FIG. 3. Third abdominal segment.
1A, *3A*. first and third abdominal segments.
1T, *2T*, *3T*. first, second and third thoracic segments.
I, *II*, *III*. first, second and third thoracic ganglia.
A. *B*. *L*. nerve trunks of the thoracic ganglia.
a, *b*, *c*. branches of nerve *A* of ganglia *I*. *1*, *2*, *3*, *4**, are sub-branches to same nerve.
con. connective.
c. r. crura cerebri.
f. furcae.
G1, *G3*, *G4*. first, third and fourth abdominal ganglia.
H. head.
l. lateral nerve-trunk of abdominal ganglia.
lm. labial muscles.
m. g. minute ganglion of the median nerve.
m. n. median nerve.
n_1c, n_2c, n_3c, n_4c. first to fourth nerve of the connectives.
ol. opening to the leg.
op. opening to the tracheal gills.
s. c. suboesophageal commissure.
s, g. suboesophageal ganglion.
sn. salivary nerve.
ten. tendon of the labial muscles.
tr. tracheae.
tr. n. tracheal nerve.
tv. n. transverse nerve.
v. ventral nerve-trunk of abdominal ganglia.

FIG. 4. Dorsal view of the head. Lettering as in Fig. 7.

FIG. 5. Ventral view of the head.

FIG. 6. The mandibular nerve.

FIG. 7. Lateral view of the nerves of the head.
a. antennal nerve.
ao. aorta.
ap. apodeme.
ar. arched nerve.
b, *b*. brain or supraoesophageal ganglia.
cl. clypeo-labral nerve.
con. connective.
cr. crura cerebri.
d. s. salivary duct.
e, *e*. simple eyes.

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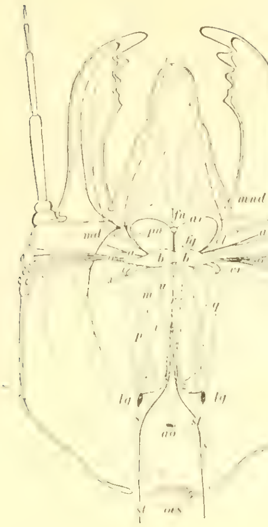
* Other numbers in these and following figures designate main branches of the different nerve trunks.



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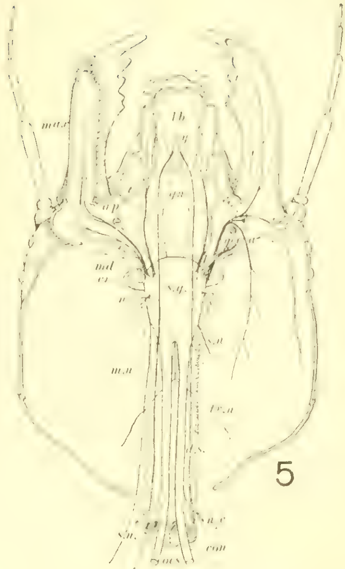

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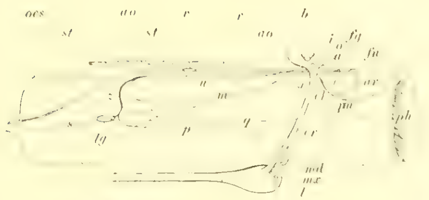

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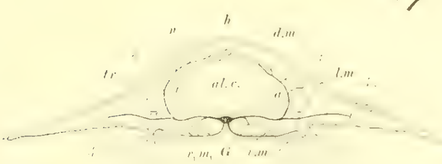

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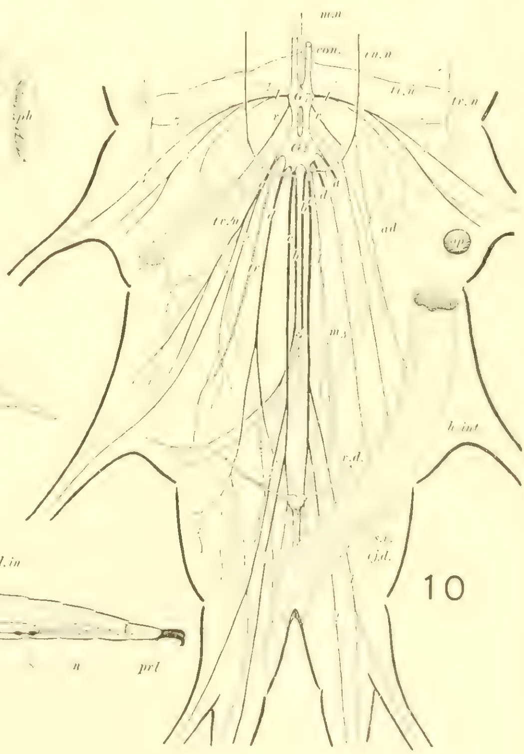

10

A. G. Hammar del.

fg. frontal ganglion.
fn. frontal nerve.
g. ganglion of the mandibular nerves.
gn. gustatory nerve.
i. nerve connecting the frontal ganglion with the brain.
l. labial nerve.
lb. labium.
lg. lateral ganglion.
max. maxilla.
md. mandibular nerve.
m. n. median nerve.
mnd. mandible.
m, p, q, s, u, z. nerves of the lateral sympathetic system.
mx. maxillary nerve.
n_1c. first nerve of the connective.
o. optic nerve.
oes. oesophagus.
ph. pharynx.
pn. pharyngeal nerve.
r. recurrent nerve.
s c. suboesophageal commissure.
s. g. suboesophageal ganglion.
s. n. salivary nerve.
st. stomogastric nerve.
t. trachea in the labium.
tr. n. transverse nerve.
v. vagus ganglion.
w. nerve of the suboesophageal ganglion.
x. nerve of the brain.
y. opening of the salivary ducts.

FIG. 8. Section through an abdominal segment, showing the distribution of the nerves.
3, 4. branches of the lateral nerve.
a. adipose tissue.
alc. alimentary canal.
d. m. dorsal muscles.
G. abdominal ganglion.
g. gills.
h. heart.
l. m. lateral muscles.
n, n. nerves.
tr. trachea.
v. m. ventral muscles.
v_1m_1. fibers of the ventral muscles passing over the nerves (compare with Fig. 1, m_2).

FIG. 9. Lateral view of the larva showing the attachment of the intestinal nerve. (Compare with Figs. 1 and 10).
1-8. first to eighth abdominal ganglia.
d. d. dorsal diaphragm.
in. n. intestinal nerve.
l. in. large intestine.
n. nerve of the terminal ganglion.
oe. oesophagus.
prl. proleg.
p. v. proventriculus.
s. g. suboesophageal ganglion.
s. in. small intestine.
sm. suspensory muscles of the alimentary canal.
v. ventricle.
v. d. ventral diaphragm.

FIG. 10. Terminal portion of the nervous system of the abdomen.
a, b, c, d. nerve-trunks of the terminal ganglion.
ad. adipose tissue.
con. connective.
ej. d. ejaculatory duct.
G7, G8. seventh and eighth abdominal ganglia.
h. int. hind intestine.
in. n. intestinal nerve.
l. lateral nerve-trunk.
m. n. median nerve.
m_3. bundle of muscles in the eighth abdominal segment.
op. opening to the tracheal gills.
s. v. seminal vesicle.
tr. trachea.
tr. n. tracheal nerve.
tv. n. transverse nerve.
v. ventral nerve-trunk.
v. d. vas deferens.

A CASE OF GREGARIOUS SLEEPING HABITS AMONG ACULEATE HYMENOPTERA.

By J. CHESTER BRADLEY.

Mr. Banks* has summarized what was recorded up to the time he wrote concerning the sleeping habits of Hymenoptera. Briefly, this consisted of several observations of usually solitary aculeates either sleeping in flowers or clinging to twigs. Belfrage has observed Scolia lecontei "during the night and chilly weather in clusters, closely attached to the stems of grass and plants."

Mr. Banks' observations were made in a small patch of timothy, orchard grass and wild onion. Here he found specimens of three species of Ammophila, of two bees, and of Myzine sexcincta sleeping, but always only *one* individual on the same stem of grass. Night after night they would appear between seven and eight, and leave before five the next morning. Gradually they became less numerous. Near the patch was a field of recently cut rye, where he surmises they may previously have rested, and also a garden and bean patch.

Mr. Schwarz† records observing in southwestern Texas within a short space, four dead shrubs of Celtis pallida which harbored from fifty to seventy specimens of two species of bees asleep, and near at hand other shrubs with a smaller number of specimens.

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* Journ. N. Y. Ent. Soc. Vol. X, p. 209.
† Proc. Entom. Soc. Wash., IV, p. 24.

Always in company with the bees was a Sphegid (Coloptera wrightii) which at the time of his observations, seven-thirty on cloudy mornings, was walking slowly up and down the twigs over the bodies of the sleeping bees.

Mr. Brues‡ records several very interesting additional observations. Along the shore of Lake Michigan he found one evening both sexes of Priononyx atrata sleeping in large numbers on the thicker parts of a plant of sweet clover. In McHenry County, Ill., also on sweet clover he and Mr. Melander noticed the following species commingled in sleep: Scolia bicincta, Nysson plagiatus; Tachytes sp., and some other smaller forms. Epeolus was predominating. He has frequently observed males of Scolia lecontei resting on an umbelliferous plant in Texas. In southern Illinois he noticed males of Myzine sexcincta in abundance sleeping on a small dried plant. Mr. Brues further questions why certain plants are regularly chosen by certain species. In some cases, as that of Priononyx atrata it may have been odor, although the species does not frequent sweet clover much during the day. Scolia lecontei he shows is afforded a certain concealment by harmonizing, in the head downward position which they assume, with the plants, although they would be much more perfectly concealed on certain bright flowers which they leave alone.

On the second of June last summer I was driving in the Mt. Diablo Range along the Arroya de los Gatos near where it opens out into the extremely hot and dry Kettleman plains in the southwestern part of the San Joaquin Valley in Fresno County, California, when slightly before dusk my attention was called to a bunch of dark objects attached to a dried stem of wild oats. Upon observation they proved to be black wasps asleep, (Priononyx atrata). Looking farther I observed another and still another such group, and within the next hour, or until it became too dark to see them, I observed scores, almost hundreds of these bunches of resting wasps, sometimes on wild oats, sometimes on other plants. Each group contained from one or two to a couple of dozen individuals, and I was often able to break them off and place them in a jar before they became considerably aroused. In all I captured 490 odd individuals before total dark, about an hour's time.

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‡ Journ. N. Y. Ent. Soc., XI, p. 228.

No less than seven species of aculeate Hymenoptera were represented in large numbers, belonging to three different families, four sub-families and five genera, *and each species so far as observed was always grouped separately.* Though a group of one species were in close juxtaposition to that of another on a neighboring stem there was no intermingling of individuals.

Returning on a subsequent evening a week later (but perhaps not finding precisely the same place at a favorable time), I found the bunches of wasps less abundant, but still present, and found a few groups of an eighth species.

The species found on the first night were Chlorion (Priononyx) atratum; C. (Priononyx) bivefoleatum; two species of Sphex (formerly Ammophila-synonym of Sphex); Monedula emarginata; Steniola duplicata, and Stizus unicinctus, the last two being especially common. On the second visit the above were found, and one additional species, Sphecius fervidus Cr. On both occasions, there were a few individuals of one or two other species, notably bees, Bombus, sp., Halictus farinosus and Melissodes agilis, etc.

I am indebted to Prof. Fernald for the identification of the Sphegidæ and to Mr. H. L. Viereck for that of the others, excepting Sphecius fervidus, which is my own determination.

The vegetation in that part of the San Joaquin Valley had already for over a month been scorched dry and brown by the intense sun-heat and absence of rain. Along one side of the road in the canon the vegetation had been freshly burned off by extensive prairie fires. Along the other side was a field of recently cut grain with a narrow standing strip along the road in which were situated the groups of wasps, not only on the oats, but on one or two other dried plants. We found them at intervals for perhaps a mile or more and then it became too dark to see further. Not everywhere along the road were the conditions as above described, in some cases the bunches occuring in a tangled growth of dried weeds.

On subsequent evenings I hunted in vain for sleeping wasps in the sage brush and fox-tail grass on the plains, twelve miles distant. No trace of the wasps was to be found.

The fact that the "hostelry" described by Mr. Banks was also bordered by a field of recently cut grain may not be a mere coincidence. It is quite possible that normally these wasps are scattered through such fields when sleeping at night, and that by the

cutting of the grain are driven into the outlying standing patches. There certainly was no protection received from their gregarious sleeping, since the groups of wasps were very conspicuous objects in the failing light.

Perhaps it would require considerable knowledge of wasp psychology to be able to answer, first, why they congregate at all, instead of each sleeping on whatever stem of oats happens to be convenient, and second, why when thus congregating they ignore the similarly situated groups of other, even close related species, and choose only those of their own fellows. The wide range of the species implicated would seem to indicate that the habit is either a fundamental one, or else a general response to some peculiar environmental condition.

Entomological Laboratory, The University of California, August 1, 1907.

NOTES ON THE LIFE HISTORY OF THE LEAFY DIMORPH OF THE BOX-ELDER APHID, CHAITOPHORUS NEGUNDINIS THOS.*

By J. J. Davis, Office of the State Entomologist, Urbana, Ill.

My attention was first called to this curious dimorph by Mr. J. T. Monell, who found it at St. Louis, June 21, 1907, and had received it from Oestlund as early as 1889.

The life history of the dimorph I have found to be essentially like that of the dimorph of the European C. testudinatus Thorn., as described by Kessler.

In central Illinois the viviparous females begin to produce the dimorphs about June 1, and the latter, after crawling over the leaves for a short time, attach themselves to the veins of either surface of the leaf. There they remain in a dormant condition for two or three months. By the last of June or the first of July the parent females begin to disappear, and soon only stragglers can be found. In the latter part of August the dimorphs revive, molt several times, and become viviparous females. Subsequent generations are oviparous, and lay the eggs which are to carry the species over the winter.

The dimorphs are inconspicuous; they appear as minute flat scales lying close against the leaf, and having the same green color as the leaf.

The dimorph of C. negundinis is indistinguishable from that of C. testudinatus as described and figured by Kessler.

Here follow some of the details of the life history. Looking for this dimorphic aphid June 12, 1907, I found it common on both the upper and the lower surfaces of the leaves of box-elder at Urbana, Ill. At that time the winged and wingless normal forms were also abundant. The following figures show the abundance of the dimorph. June 15 the total number on the upper surfaces of twenty leaves was 1988, and on the lower surfaces, 2088—a total of 4076 individuals on the twenty leaves, or an average of 203+ to each leaf. July 19, on ten leaves which were only slightly infested and in a shaded situation, the total number of individuals on the upper surfaces was 214, while on the lower surfaces there were but 23 — a ratio of 9 on the upper to 1 on the lower. After July 1 the normal forms began to disappear, and by July 19 they occurred only occasionally. Between that date and August 5 none of the normal forms were noticed, although careful searches were made for them. August 5, however, I found four young of the normal form and from one of these I obtained young. She began to bear young August 13, and bore in all 73 young, of which 27 were dimorphs and the remaining 46 normal forms. Owing to my absence I was unable to trace these to the sexual forms. August 20 I found the aphids becoming suddenly abundant on the box-elder leaves. These aphids had a decidedly reddish tinge, and were, I infer, dimorphs which had molted; since a dimorph that molted August 27 later developed into a reddish normal form. Both out-of-doors and in the insectary I have noticed the dimorphs in the act of molting.

It is probable that the fully developed dimorphs are the mothers of the sexual forms, although I have no positive evidence of this. I infer, also, that the mothers of the dimorphs may belong to any of the earlier generations.

The dimorph is capable of locomotion. In a chimney cage containing a small box-elder plant I placed pieces of leaves bearing dimorphs. As soon as the pieces of leaves began to dry up the dimorphs moved from them to the fresh leaves. In another instance the dimorphs, when transferred directly to fresh leaves with a brush, attached themselves readily to these.

I have found this dimorphic form in many localities in northern and southern Illinois, but most abundantly at Urbana.

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* Read at the Chicago meeting, December 30th, 1907.

Coccinellid and chrysopid larvae have often been observed feeding on the dimorph.

The first paper on the American dimorph is an article by Mr. L. C. Bragg in Entomological News for December, 1907. His statement that it does not molt or reproduce is incorrect. In comparing the European dimorph with the American dimorph he states that the former has fourteen leaf-like appendages on the abdomen and the latter twenty-two; I find, however, that both the American and the European dimorphs have twenty-two flabella on the margin of the abdomen. Mr. Bragg mentions the maple-aphis (Chaitophorus aceris) as being the species that produces the European leafy dimorph. This was supposed to be the case until Kessler proved that they were borne by Chaitophorus testudinatus and not by C. aceris. He found that C. aceris produces dimorphs, to be sure, but dimorphs without leafy appendages.

Professor Oestlund, in a paper on this dimorph in Entomological News for March, 1908, summarizes the more important literature on the European dimorph. He refers to the species as occurring on "maples," but informs me by letter that he used this name for Acer negundo, the common box-elder. He uses the name testudinatus instead of negundinis for this species; but it appears from Kessler's paper that the adults of testudinatus are quite different from those of negundinis—so different that we can scarcely regard the two species as one.

THE GENUS CORIZUS.

With a Review of the North and Middle American Species.

By J. C. Hambleton.

INTRODUCTION AND ACKNOWLEDGMENTS.

The writer wishes to express his sincere thanks to those who have contributed to the success of this work by allowing him the use of their collections. Among these should be mentioned first Prof. Herbert Osborn who allowed the use of his private collection as well as that of the Ohio State University. Prof. Comstock sent the collection belonging to Cornell University, and Mr. Heidemann of the National Museum sent his private collection of several hundred specimens. The collection belonging to the Colorado Agricultural College was also at the writer's disposal. Without this extensive material, it would have been impossible to arrive at many definite conclusions concerning the genus.

The first insect of this genus to be described was crassicornis. Linneus in 1758 gave it a brief description and included it in his large genus Cimex. Fabricius, in 1794, described two more species, sidae and hyalinus, under the generic name of Lygaeus, but later, in 1803, he changed them to the genus Coreus. In 1814 Fallen created the genus Corizus and gave it the following limitations: "Corpus oblongum; antennarum basali brevi; ultimo subclavato; thorace planiusculo; hemelytris oblique truncatis; membrana longitudinaliter multinervosa." In 1828, in his Hemiptera Sueciae, pages 41 to 45, he includes six species, not all of which, however, have remained in this genus. The only American species included here is crassicornis, a very common European insect.

Signoret in 1859, in the Ann. Soc. Ent. Fr., published a monograph of the genus. This is a notable work and has served as the basis of nearly all the work that has been done on the genus since his time. He recognized the practical impossibility of separating the genus into natural groups, or subgenera. He includes fifty-four species from all parts of the world, and describes many new American species, some of which have not withstood the test of time, probably because his material was not abundant enough for him to understand their variations.

Stal, in 1870, in his Enumeratio Hemipterorum, Vol. 1, divides the genus into three sub-genera as follows: Liorhyssus, Niesthrea and Arhyssus, and follows this up in the third volume of the same work three years later on pages 97 and 98 by abandoning the genus Corizus entirely and creating from it three new genera, Liorhyssus, Peliochrous and Stictopleurus. Fieber, in 1861, had also made three genera of this genus, namely: Rhopalus, Corizus and Brachycarenus.

Lethierry and Severin in 1893 have abandoned these subdivisions and retained the genera Corizus and Maccevethus.

DESCRIPTION OF THE GENUS.

Body, narrowly ovate or oblong-ovate. Head short, conically produced in front of the eyes and narrowing abruptly behind. Rostrum reaching the posterior coxae. Antennae slender with first and last segments thickened, the former short, scarcely reaching or but slightly passing the apex of the head. Pronotum trapezoid shaped, crossed near its anterior margin by the transverse suture which is more or less plainly marked, and is interrupted at its middle by the median line. Scutellum a little longer than wide. Membrane with numerous simple veins. Metapleura dilated posteriorly. Legs medium, unarmed, the posterior pair slightly the longest. Body pubescent and punctured.

Taken as a whole the genus is truly cosmopolitan, being found both in the temperate regions and in the tropics. It is probably more abundant in the latter but is widely distributed in the former. One species, hyalinus, has been reported from Australia and the Philippines, Europe, Asia, Africa and America. Another species, crassicornis, is circumpolar in its distribution, being found in northern and central Europe and in northern North America, and entirely across Siberia. Still other species, such as scutatus and tuberculatus, as far as known, are confined to comparatively small areas.

Little is known of their habits. They probably hibernate, in temperate regions, in the adult state and deposit their eggs in early summer when their food plants have developed sufficiently to furnish food for their young, and reach maturity in early autumn. None of the species are sufficiently numerous to be of economic importance, though under changed conditions they might easily become so.

BASIS OF SEPARATION OF SPECIES.

Many mistakes have been made in the past by placing too much confidence in color characters in the determination of species. This is very unsafe, as it would be difficult to find a genus more variable and inconstant in this respect. In this paper structural characters alone are used for this purpose. A careful study of an abundance of material has shown that these are reasonably constant. The form and position of the antenniferous tubercles and rostral lobes are excellent characters to separate some of the species. The nature of the transverse suture on the pronotum, and the form of the scutellum serve for others. The genitalia give us excellent characters for several species, and the general form of each species varies but little, though the size may vary, and in several cases is quite distinctive. There is still another character that is good in a number of cases, though it is difficult of access and hence little use has been made of it. This is the nature of the dorsal sutures between the third and fourth, and fourth and fifth segments. It is a character that seems to be quite constant though at times the middle portions of these sutures may be so obliterated that it is difficult to distinguish them.

ARTIFICIAL KEY FOR THE DETERMINATION OF SPECIES.

1. (a) Last segment of abdomen short and broad, truncate in female and rounded in male . . . . **hyalinus**
   (b) Not as above . . . . 2.
2. (a) Antenniferous tubercles prominent; transverse suture terminating in a loop . . . . 3.
   (b) Not as above . . . . 4.
3. (a) Insect large. Connexivum spotted . . . . **crassicornis**
   (b) Insect small. Connexivum unspotted . . . . **viridicatus**
4. (a) Scutellum broad at the tip, rounded . . . . 5.
   (b) Scutellum narrow at tip and pointed . . . . 6.
5. (a) Antenniferous tubercles broad, sternum not black . . . . **scutatus**
   (b) Antenniferous tubercles very long, reaching almost to apex of head . . . . **tuberculatus**
   (c) Sternum black . . . . **indentatus**
6. (a) Connexivum unspotted . . . . **lateralis**
   (b) Connexivum spotted . . . . 7.
7. (a) Insect large, light colored . . . . **validus**
   (b) Insect medium, dark, last segment in female pointed . . . . 8.
   (c) Last segment in female not pointed . . . . 9.
8. (a) Last segment very long pointed . . . . **punctatus**
   (b) Last segment medium . . . . **nigristernum**
9. (a) Abdomen much broader than thorax, with black transverse band . . **sidae**
   (b) Insect small, antennae short, scutellum large . . . . **parvicornis**

DESCRIPTION OF SPECIES.

Corizus hyalinus Fabricius.

Lygaeus hyalinus Fabricius, Ent. Syst., IV, p. 168 (1794).
Coreus hyalinus Fab., Syst. Rhyng., p. 201 (1803).
Corizus hyalinus Stal, Hem. Fab., I p. 68 (1868); Uhler, Geol. Bull. I, No. 5, p. 34 (1875); Obs. upon Heter. Hem. of Lower Cal., p. 237 (1895); Sum. of Hem. of Japan, Pres. to U. S. Nat. Mus. by Prof. Mitzukuri (1896); List. of Hem. Heter. of Las Vegas Etc., from Proc. U. S. Nat. Mus., XXVII, pp. 349-364 (1894); On Hem. Heter. of Grenada, W. I., pp. 180-181 (1894); Oshanin, Verzeichnis Der Palearktischen Hemiptern. I, p. 227 (1906).

An easily recognized species, with adbomen truncate in female and rounded in male. Transverse suture prominent and black, lateral borders of pronotum light. Length of female, 5.7 to 6.4 mm., width 2.3 to 2.5 mm., male, length, 5.5 to 5.8 mm., width 1.8 to 2 mm.

Head triangular, narrowing from the eyes forward. Antenniferous tubercles not prominent. Rostral lobes well marked, not thickened at extremities. Eyes prominent. First segment of antennae not reaching apex of head.

Pronotum: Transverse suture very wide and close to the anterior border. Scutellum with lateral borders almost straight and slightly elevated except at the tip, which is not excavated, and a poorly defined ridge throughout its length. Abdomen truncate in female and rounded in male; decidedly wider than the thorax especially in the female. Wings longer than the abdomen. Pubescence not abundant and punctuations small.

Color: The color of this species varies exceedingly, even in individuals taken in the same locality, though the markings are quite constant. In general, the ground color may be said to be a pale yellow, though this varies to red on one hand and to dark brown or black on the other.

Head: Transverse line across the base, a curved line backward and downward from the eyes, irregular lines between the eyes and rostral sutures, black. Antennae yellow or brown, pointed with black dots which on the upper surface are sometimes confluent, forming a black line.

Pronotum: Transverse suture, posterior angles, and punctuations except on lateral borders, black. This arrangement of color produces the lighter colored borders, which are so characteristic of this species. Scutellum same as pronotum, with the elevated ridges usually, and the apex always, of a lighter color, usually yellow.

Abdomen: Above, black with several light spots on or near the median line. Connexivum red or yellow, sometimes with a dark spot on each segment. Sixth segment black, with five yellow or reddish spots on the margin in the male, and with margin entirely yellow in the female. This margin is somewhat wider at the apex. Wings hyaline, nerves yellow or reddish. Apex of coreum usually red or brown. Entire under side yellow or reddish, except sternum, which is black.

This is a cosmospolitan, tropical and sub-tropical species, extending as far north in America as South Dakota and Iowa, and south into Mexico, Middle America and the West Indies. It is one of the most common southern European species, and is found south as far as Cape Colony in Africa, and Australia, and has been reported from the Philippines. Specimens are at hand from Colorado, Arizona, Mississippi, Mexico, Wyoming, South

Dakota, Iowa, Ohio, Bermuda and Hayti. It is reported by Uhler from Lower California, New Mexico, and Grenada, W. I. Oshanin in 1906 reports it from southern Russia, Caucasia, Turkestan, Japan and Chili. (For further references and synonomy, see Lethierry and Severin's General Catalogue.)

Corizus crassicornis Linneus.

Cimex crassicornis Linneus, Syst. Nat., 10th Ed., I, p. 448; 12th Ed., I, p. 727; Faun. Suec., p. 254.
Rhopalus punctiventris Dallas, List. II, p. 526 (1852).
Corizus novaeborecensis Sign., Ann. Soc. Ent. Fr., p. 97 (1859).
Corizus borealis Uhler, Proceed. Acad. Phila., p. 284 (1862).

A large species easily recognized by its broad vertex and spotted connexivum. Length of female, 7.5 to 8.5 mm., width 3 to 3.5 mm. Male, length 6 to 7 mm., width 2.5 to 3 mm.

Head: Vertex broad, due to the thickened rostral lobes which extend almost to the apex. Antenniferous tubercles prominent, angular, and extending well forward. First segment of antennae passing beyond the apex of the head. Eyes not so prominent as in hyalinus because of the more prominent antenniferous tubercles.

Pronotum rather sharply angled anteriorly. Transverse suture terminating at either side in a closed loop. Scutellum gently narrowing from base to near the apex, where it expands slightly, and is rounded and excavated; borders slightly raised.

Abdomen rather abruptly widened at the third and fourth segments, especially in the female. Genitalia: Dorsal plate in female broadly triangular and rounded at the apex. Ventral plate compressed laterally, posterior angles rounded. Wings little, if any, longer than the abdomen. Punctuations small and pubescence very short.

Color: Above brownish gray, sometimes nearly black. Broad stripe on first segment of antennae, spots between ocelli and compound eyes, transverse suture on pronotum, black. The scutellum is usually much darker at its base and has the small depression at its apex black. Wing nerves light with few spots.

Abdomen black with three light spots, one occupying the middle of the third, fourth and fifth segments and two on the fifth, whose posterior border is also light. These spots may vary in size and may be fused, forming an inverted V-shaped spot. The sixth has two large yellow spots, one on either side, that reach the extremity. Connexivum light with a dark spot on each segment. Under side and legs yellowish gray, the latter spotted over with black. Large irregular black blotches on inner side of posterior femurs.

The color of this species, as of others, varies greatly. The ocelli may be entirely surrounded by a black spot which reaches the thorax. The transverse suture may be brown or gray, like the rest of pronotum. The black spots on wing nerves, depression at apex of scutellum, and spots on connexivum may be light or reddish brown. In very dark individuals the head, pronotum and scutellum may be heavily spotted with irregular blotches of black, and the black spots on connexivum may extend to the underside, and there may be a few small black spots, one on the posterior border on each side of the first, second and third

segments below. In such cases the spots on the abdomen above may all but disappear, except those on the sixth segment.

Rhopalus punctiventris Dallas and Corizus novaeborecensis Sign. should undoubtedly be referred to this species. Specimens from the east and from the west have been carefully compared with European specimens kindly sent by Dr. Horvath from Hungary. They are identical in all structural characters and do not differ more in color than do individuals taken in the same locality.

This is also a cosmopolitan species. Oshanin reports it as follows: All of Europe, Canaries, Tunis, Syria, all of Russia, Caucasia, Turkestan, Siberia and Japan. Uhler in various papers reports it from Colorado, Arizona, California, Washington, British America, Walrussia, Canada, Massachusetts, Pennsylvania, New York, Mackenzie River, Yukon, Saskatchewan and Lower California. Specimens are at hand from Washington, Oregon, Utah, British Columbia, California, Wyoming, South Dakota, Ohio, New York, and New Hampshire.

Corizus viridicatus Uhler.

Corizus viridicatus Uhler, Hayden's Survey of Montana, IV. Zool. and Bot., p. 404 (1872).
Corizus hyalinus Uhler, Geolog. Bull. II, No. 5 (1875), pp. 34 and 35.

A slender species, often greenish in color with the black spot on sixth segment quite prominent. Length of female, 5.5 to 6 mm., width 2 to 2.5 mm. Male, length 5 to 5.5 mm., width 1.8 to 2 mm.

The head pronotum and scutellum of this species closely resemble those of its near relative, crassicornis. They are, however, smaller, and the scutellum has its narrowest portion a little farther from the apex. The abdomen is but little wider than the thorax, and hence the sides are very nearly parallel.

Genitalia: Dorsal plate of female broadly rounded; ventral plate compressed laterally, uniform in width, posterior angles but little rounded. Dorsal plate of male broadly rounded; ventral plate much narrower at its middle point, and angles rounded. Wings a little longer than the abdomen, and opaque, thus hiding the abdominal picture except the anal spot. Pubescence soft and punctuations small.

Color: Light gray, often tinged with green, both above and below. This color, while predominant in the species, is not universal. Occasionally a specimen may be found with the thorax above, all black, except the scutellum, and the body below a reddish yellow. A broad stripe on basal segment of antennae, ocellar tubercles and a line between them and the eyes, black. Transverse suture and disk of abdomen usually black. Two broad stripes on last segment of abdomen and three spots about the middle of the disk, light. It is not uncommon to find specimens with the light color predominating on the disk, and all color may disappear except the spot on last segment.

This species was described by Uhler in 1872, but later, in 1875, he abandoned it, having come to the conclusion that it was but a variety of hyalinus. It now seems best to revive it as it certainly

is not a variety of hyalinus, but is closely related to crassicornis, from which it differs enough, however, to give it good specific rank. It seems to be confined to the west. Specimens are at hand from Colorado, Utah, California, Wyoming, Nebraska, and Assiniboine, B. A.

Corizus scutatus Stal.

Rhopalus scutatus Stal., Freg. Eug. resa. Inst., p. 239 (1859).
Corizus jactatus Signoret, Ann. Soc. Ent. Fr. p. 81 (1859).

Female, length 8 to 9 mm., width 3 to 4 mm. Male, 7.5 to 8 mm., width 3 to 3.5 mm.

Head: Antenniferous tubercles broad but not long. Rostral lobes clearly marked, narrow and not reaching the apex of the head. The whole upper surface of the head is rough and tubercular. First segment of antennae just reaches the apex of head.

Pronotum: Transverse suture on a tubercular ridge which reaches quite to the borders of pronotum. Scutellum broad and rounded at the apex which is excavated.

Abdomen prominently widened at third and fourth segments, especially in the female. Genitalia: Dorsal plate in the female broadly triangular and gently rounded at the apex. Ventral plate widest at its middle and extending backward almost as far as does the dorsal plate. In the male the middle part of ventral plate is very narrow and the posterior angles rounded. Wings about as long as the abdomen. Punctuations not prominent. The whole insect is covered with a rather thick growth of short hair.

Color: Dull reddish brown above and tinged with yellow below. The median line on pronotum is usually lighter in shade and extends to the depression on the scutellum. In very dark specimens the apex of head and first three segments of antennae are nearly black, and a black line is found between the eye and ocellus. The scutellum may also be very dark except median line and borders. In very light specimens the color is uniform throughout the whole upper surface. Disk of abdomen black, with usually two small yellow spots on anterior borders of second, fifth and sixth segments, and another in the middle of the fourth. The sixth has two yellow stripes, one on either border, which sometimes fuse with the spots. The connexivum is light with a large brownish or reddish spot on each segment. This color sometimes approaches that of the connexivum and they are then almost invisible. Sometimes there is a line on each side of the abdomen below, dark reddish brown. Legs with a few small black points.

This species is not widely distributed, being, so far as known, confined to the western United States. Specimens are at hand from Oregon, Utah, Wyoming and California.

Corizus indentatus n. sp.

Somewhat resembling scutatus but smaller and more hairy. Length of female, 4.5 to 6 mm., width 2 to 3 mm. Male, length 4.5 to 5 mm., width 2 to 2.5 mm.

Head: Antenniferous tubercles small but rather sharp, very close to the eyes. Rostral lobes short and obscure. First segment of antennae reaches a little beyond the apex of the head. Upper surface rough and tubercular.

Pronotum tubercular, especially in the region of the transverse suture which is often difficult to trace on this account. This suture forms a rather deep depression on either side of the median line. Scutellum rather broad and rounded at apex, with borders slightly raised near the end which is not excavated.

Abdomen but little wider than pronotum. Genitalia pretty much as in scutatus, though the entire sixth segment of the female is relatively shorter, and the ventral plate in the male is not so narrow at its middle point. Wings a little longer than abdomen. Whole insect covered with rather dense hair.

Color, reddish brown with no distinctive markings. The pronotum is sometimes irregularly blotched with black, and its posterior border, with the base of the scutellum may be dark or almost black. Beneath the color is lighter, often tinged with yellow and minutely spotted with red. Sternum black, and often a dark brown line on either side of abdomen below, near the borders. The first and second segments of disk of abdomen are black, and the remaining four may be black also, but usually are brown. The third has two small spots on anterior margin and the fourth a rather large oval spot at its center; the fifth has two smaller oblique spots at its anterior margin and several small round spots below these; the sixth with the conventional yellow lateral stripes and the long black spot between them. Connexivum alternating dark and light, sometimes one predominating and at others the other. The dark portions are frequently ornamented with one or more small round spots of a lighter color. The legs are reddish yellow spotted with brown. Wing veins with a few brown spots. Membrane with a slight reddish tinge.

This also is a western species, and was recognized as new by Uhler who proposed for it the name indentatus, but never published a description. Specimens are at hand from British Columbia, Washington, Oregon, California, Wyoming and Colorado.

Corizus tuberculatus n. sp.

Medium in size, with antenniferous tubercles abnormally long. Rather yellowish in color. Length of female, 6 mm., width 2.7 mm.

Head: Antenniferous tubercles very long, reaching almost to the apex of the head and diverging widely. Rostral lobes small but distinct. First segment of antennae passing the apex of head.

Pronotum: Transverse suture bordered anteriorly by a tubercular ridge. Anterior angles not prominent. Scutellum broad at the apex, rounded and excavated.

Abdomen not much wider than thorax and sides nearly parallel. Genitalia of female very similar to scutatus. Wings equal to abdomen in length. Pubescence slight. Punctuations prominent.

Color: Reddish yellow, a little darker above than below. Head a little more tinged with red. Eyes dark. Small black spots between ocelli and eyes. Posterior angles of pronotum darker. Scutellum light, unspotted. Disk of abdomen black with a small elliptical spot at its center and six smaller ones surrounding, and at some distance from it. Several other very small round spots are scattered over the surface. The posterior border of the fifth and all of the sixth segments light. The latter has a darker portion at its middle. This spot has the same form as the black stripe that is so common in this genus but is not black as is usually the case. Beneath, the insect is unspotted except the sternum which is black.

This insect is described from two females taken by Mr. Heidemann at Pullman, Washington.

Corizus lateralis Say.

Coreus lateralis Say, Jour. Acad. Phila., IV, p. 320 (1825); Complete Writings, II, p. 245.

Rhopalus punctipennis Dallas, List., II, p. 526 (1852).

Corizus lateralis Signoret, Ann. Soc. Ent. Fr. p. 97 (1859); Uhler, Hayden's Survey Mont., IV, Zool. and Bot., p. 404; Bull. Geol. and Geog. Survey, II, p. 301, and III, p. 408; Proc. Boston Soc. Nat. Hist. XIX, p. 386. Distant, Biol. Cent. Amer., pl. XVI, fig. 9 and 10 (1881).

This is a light colored species, red and yellow predominating. Eyes prominent and apex of head sharp pointed. Length of female, 5.5 to 6 mm., width 2.5 to 3 mm. Male, length 5 to 5.5 mm., width 2 to 2.5 mm.

Head: Antenniferous tubercles very small and close to the eyes. Rostral lobes prominent though not reaching the apex. First segment of antennae just reaching the apex of the head. Eyes prominent.

Pronotum much narrower in front than behind. Transverse suture reaching to the borders of the pronotum. Scutellum narrowing rather abruptly near the base; slender near the apex which is rather sharp and somewhat elevated. Borders of apical portion raised.

Abdomen but little wider than pronotum. Genitalia: Dorsal plate in female broadly triangular with rounded apex. Ventral plate with posterior angles evenly rounded. Dorsal plate in male produced and spatulate. Ventral plate wider at the edges and middle, almost as long as dorsal plate. Wings as long as or a little longer than the abdomen. Pubescence medium. Punctuations coarse but not tubercular.

Color: This species is so variable in color that little use can be made of this character for the purpose of identification. Red and yellow predominate, and black is usually wanting except on disk of abdomen and wing spots, and even from here it sometimes disappears. The red varies from bright to pale. In some cases the head and thorax are red and the under side of abdomen a bright yellow. Occasionally lateral reddish brown stripes are found on the under side of the abdomen, especially in the males. The color scheme on the disk of abdomen consists of a large transverse spot at the base, two lateral longitudinal areas about the middle, the spot on anal segment and three small spots on the enclosed area, black or reddish. These areas may increase in size until they cover the entire abdomen except the anal segment, or they may entirely disappear. Connexivum, except in very rare cases, without spots. Sternum black, reddish or colorless.

This is a widely distributed species in the U. S. and seems to be more abundant in the south. Specimens are at hand from practically every part of the United States.

Corizus validus Uhler.

Corizus validus Uhler, Proc. Ent. Soc. Wash. p. 370 (1893).

Closely resembling lateralis in form and color. Very large. Rare. Length of female, 7 to 8 mm., width 3.5 to 4 mm. Male, length 7 to 7.5 mm., width 3 to 4 mm.

This insect differs so little from lateralis that it is doubtful if it should be retained as a separate species. The head and thorax characters are practically identical. The scutellum is a little broader in the last third of its length, and the apex is a little more sharply pointed.

There is little difference in the genitalia, and what is noticeable might disappear if sufficient material were at hand. In the female the posterior angles seem to be rather more rounded than in lateralis, and in the male the widening of the middle portion of the ventral plate seems to be a little more pronounced, thus giving it a longer and sharper point when viewed from the side. In the

female the ventral plate is frequently notched at the apex. This rarely occurs in lateralis.

In color there is little difference. It has the same variable character, and the dorsal picture is often the same. The connexivum, however, usually has a small spot on each segment, while in lateralis this rarely occurs.

It is not widely distributed, and seems to be confined to the mountains. Specimens are at hand from Cal., Utah and Wyo.

Corizus sidae Fabricius.

Lygaeus sidae Fabr., Ent. Syst., IV, p. 169 (1794).
Coreus sidae Fabr., Syst. Rhyng., p. 201 (1803).
Coreus (Rhopalus) sidae, Guer. in Sagra. Hist. de Cuba Ins. p. 385 (1857).
Rhopalus pictipes Stal, Freg. Eug. resa. Ins. p. 239 (1859).
Corizus sidae Sign., Ann. Soc. Ent. Fr., Ser. 3, VII, p. 95; Stal, Hem. Fabr., I, p. 69 (1868).
Corizus mexicanus Sign. Ann. Soc. Ent. Fr., Ser. 3 VII, p. 95 (1859).
Corizus proximus Sign., Ann. Soc. Ent. Fr., Ser. 3 VII, p. 96 (1859).
Corizus nebulosus Sign., Ann. Soc. Ent. Fr., Ser. 3 VII, p. 98 (1859).
Corizus pictipes Stal, Ent. Zeit. XXIII, p. 307 (1862).
Corizus anticus Sign., Ann. Soc. Ent. Fr., Ser. 3 VII, p. 99 (1859).
Corizus ventralis Sign., Ann. Soc. Ent. Fr., Ser. 3 VII, p. 92 (1859); Distant, Biolog. Cent. Amer. pl. XV, fig. 23.

Small pointed head; abdomen broad and short. Abdominal picture appearing as a dark band across the middle of abdomen. Length of female, 5.6 to 6.3 mm., length of male, 4.4 to 5.5 mm. Female, width 2.9 to 3.1 mm., male, width 2 to 2.5 mm.

Head narrowly triangular. Antenniferous tubercles scarcely visible and placed very close to the eyes. Rostral lobes short but well defined. First segment of antennae scarcely reaching apex of the head.

Pronotum narrowing decidedly anteriorly and quite convex. Transverse suture bordered in front by a tubercular ridge. Scutellum rather sharply pointed and excavated at the tip.

Abdomen short and much wider than thorax, narrowing rapidly from fourth segment, and becoming depressed. Genitalia: Dorsal plate in female broadly rounded at the apex. Ventral plate short, uniform in width, posterior angles round. Dorsal plate in male convex, short. Ventral plate much narrower at the middle than at the edges. Wings longer than the abdomen. Pubescence soft on the body and heavier on the legs. Punctuations rather coarse.

The general color varies from dark brown to gray or reddish yellow, usually rather thickly covered over with very small brown or bright red spots, and often with both colors intermingled. The whole insect, especially in the tropics, often has a metallic luster, making it the most beautiful of the genus when viewed under the lens. A dark line begins on the head and extends backward on the pronotum, where it widens and is lost.

The abdominal picture varies greatly, but the first segment is usually darker while the second is light except at its middle where there are frequently three small spots. The third, fourth and fifth are nearly always dark, and often black; the fifth having a light spot at its center. The sixth segment is all light in the female and with a dark stripe at its middle in the male. Connexivum light; the third, fourth and fifth segments having each a darker spot which usually has a light spot or line at its center. This latter may be absent, as also the dark spot on the third segment. Sternum black. On the legs, the small spots that cover the body, form well marked rings.

This species is widely distributed in tropical America. Berg, in his Hemiptera Argentina, p. 93 (1879), reports it from the Argentine Republic, Patagonia and Brazil. Uhler in various articles reports it from Texas, Indian Territory, Arizona, Mexico, Brazil, Maryland (once only), and Lower California. Specimens are at hand from Georgia, Florida and Arizona, in the United States, and from Mexico, Guatemala, Cuba, Hayti, Trinidad and St. Vincent.

Corizus parvicornis Signoret.

Corizus parvicornis Sign., Ann. Soc. Ent. Fr., p. 301 (1859).

Very small. Short and thick in appearance. Neck short. Length of female 3.5 to 5 mm., width 2 to 2.5 mm. Male, length 3 to 4 mm., width 1.5 to 2 mm.

Head: Antenniferous tubercles short and rounded. Rostral lobes small and obscure. Antennae short. First segment reaching apex of head. Head narrowing very abruptly behind the eyes, thus bringing the latter very close to the angles of the prothorax.

Pronotum short. Transverse suture much curved and bordered anteriorly by a prominent ridge. Scutellum large, about one-third as long as the abdomen; apex broad though rather abruptly drawn to a point; the borders about the large excavation prominently raised.

Abdomen a little wider than prothorax. Genitalia: Dorsal plate in the female a little produced and broadly rounded. Ventral plate widest at its middle with posterior angles broadly rounded. In the male the dorsal plate is much produced, and the ventral is equal in width throughout. Wings, little if any longer than the body, and sometimes not reaching the extremity of the abdomen. The whole insect has a short thick appearance which is very characteristic. It is thinly covered with rather long hair. Punctuations large.

Color: Varying from gray to almost black, without distinctive markings except on the disk of the abdomen, which is black or brown. There is a small obscure light spot about the middle of the fourth segment, and two each on the anterior borders of the third and fifth. The transverse suture, and a few spots on the wing veins are black. The sixth segment has the common black spot in the middle and sometimes the light borders may be divided by the enlargement of this spot, thus forming two light spots at the anterior margin. Connexivum spotted. The sternum is black and the legs are spotted with the same color or with brown. These spots usually form pretty well pronounced rings. In very dark specimens the whole under side is covered over with dark or black blotches.

This is the smallest species of the genus and seems to be rather rare. Specimens are at hand from California, Texas and Mexico.

Corizus nigristernum Signoret.

Corizus nigristernum Sign., Ann., Soc. Ent. Fr., p. 100 (1859).
Corizus Bohemani Sign., Ann. Soc. Ent. Fr., p. 86 (1859).

Very dark in color. Spot on abdomen above, in form of an X. Length of female 5.5 to 6 mm., width 3 mm. Length of male 5 to 5.5 mm., width 2.5 to 3 mm.

Head: Eyes rather prominent. Antenniferous tubercles small and close to the eyes. Rostral lobes short, clearly marked.

Pronotum decidedly narrower in front than behind. Transverse suture a slender line bordered anteriorly by a slight elevation. Median line prominent.

Scutellum sharp pointed and not excavated. Lateral borders raised, except at their middle points.

Abdomen but little wider than prothorax. Genitalia: Dorsal plate in female a little broader than long; apex pointed. Ventral plate widest at its middle, and the posterior angles practically wanting. Dorsal plate of male somewhat produced and broadly rounded; ventral plate widest at the middle; posterior angles rounded. Punctuations normal. Pubescence short and soft. Wings about as long as the body.

Color: Rather dark reddish or yellowish brown, frequently almost black. Apex of head, and small spots between ocelli and eyes, black. Median line of pronotum light, extending onto scutellum, the borders of which are also light on the elevated portions. Disk of abdomen dark brown or black, with a light spot, near its middle, in the form of an X. This spot may be much reduced, or it may be enlarged to form a large irregular blotch. Last segment light, with a black stripe very much enlarged laterally, enclosing two light spots at its anterior border. This enlargement is often obscure or wanting, especially in the female. Connexivum, light, spotted with black. Beneath, uniform light yellow or reddish brown. Sternum black. Wing veins spotted with dark red or black. Legs yellowish with dark spots.

This species is eastern in its distribution, and apparently does not extend far south. Uhler has reported it from the east and also from the south-west, Arizona, Texas, California, and Lower California, but the species to which he refers here is probably indentatus, which has a slight superficial resemblance to nigristernum. Specimens are at hand from Canada, Ohio, Pennsylvania, New York, West Virginia, Virginia, Maryland, District of Columbia and Missouri.

Signoret evidently had two extreme types of this insect and hence described it twice as different species.

Corizus punctatus Signoret.

Corizus punctatus Sign., Ann. Soc. Ent. Fr. p. 81 (1859).—Distant, Biol. Cent. Am., pl. XVI, fig. 8 (1881).

Somewhat resembling nigristernum in general shape and color, but with last segment of abdomen much more produced. Length of female 5.5 mm., width 2.5 mm. Length of male 4.5 mm., width 2 mm.

Head: Eyes very prominent. Antenniferous tubercles short and broad, rounded at the tips. Rostral lobes slender but reaching almost to the apex of the head, but not clearly marked. First segment of antennae slightly passing the apex.

Pronotum much narrower in front than behind. Region of transverse suture not tubercular. Scutellum rather sharp with a very small excavation at the apex.

Abdomen very little wider than the thorax. Sixth segment very long, pointed. Both dorsal and ventral plates in the female are sharply triangular, and the ventral is but little shorter than the dorsal. In the male the dorsal is somewhat produced with apex rounded. Ventral plate much widest at its middle point. Wings about as long as the abdomen. Pubescence short and soft. Punctuations normal.

Color, dark reddish brown or almost black above, and reddish yellow or yellow, below. The eyes and ocelli are red, the latter bordered by a black spot. The head has a blackish longitudinal line running throughout its length. Wing

veins sparingly spotted with black. Abdomen above, black with three small light spots, one on the fourth segment and two on the fifth, the sixth has the conventional black stripe bordered by lighter color. The connexivum is light with a small black spot on each segment.

Too much confidence should not be placed in this color description. The insect is rare, at least in collections, and material at hand was not sufficient to determine the limits of its variation. It is however, easily distinguished from all others by its genitalia. Specimens are at hand from Texas, Mexico and Hayti.

PHYLOGENY.

Any attempt to trace the lines of dispersal or phylogeny of this genus must be merely tentative until more is known of their life histories, food plants, etc. As far as known at the present time, hyalinus is by far the most widely distributed member of the genus, and from the fact that it is found in the tropics and sub-tropics, completely around the earth, we must concede to it very great antiquity. It probably penetrated into the United States by way of Mexico, and thence spread over the entire southern half of the country.

Sidae undoubtedly has originated in Central America or the West Indies, and has spread as far north and south as the climate or its food plant will permit. Parvicornis is rather an extreme type that is difficult to account for, though it is probably an offshoot from sidae, as it seems to be more closely related to it than to any other.

Crassicornis is circumpolar in its distribution, being found entirely around the earth in the north temperate zone, and even far into the boreal regions of North America and Eurasia. It is probable that it originated in the latter continent and thence found its way to America. The winds and tides would favor a migration in this direction, rather than in the opposite. Viridicatus is plainly a mountain offshoot from this species.

Scutatus, indentatus and tuberculatus are three species that in many respects, are closely related, and seem to have sprung from a common type. They are all western, and as far as known, not widely distributed, and occupy the same territory. The remaining four species, namely, lateralis, validus, nigristernum and punctatus, form one lateral branch that seems to have sprung from the hyalinus type. Lateralis is the most widely distributed and occupies, practically, all of the United States. Validus is a mountain form very closely related to lateralis, and is not com-

mon nor widely distributed. Nigristernum occupies the eastern United States and Canada, while its closely related species, punctatus, is from the southwest, Mexico and the West Indies.

Hyalinus and crassicornis are the only American species that are also found in the Old World. It seems more than probable that these have both emigrated to this country, hyalinus by the southern route and crassicornis by the northern, and here given rise to our peculiarly American species. From the latter, undoubtedly we get viridicatus, while all the remaining species seem to have sprung from the hyalinus stock.

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EXPLANATION OF PLATES.

Plate VIII.

Corizus hyalinus ♀
" crassicornis ♀
" tuberculatus ♀
" sidae ♂

Plate IX.

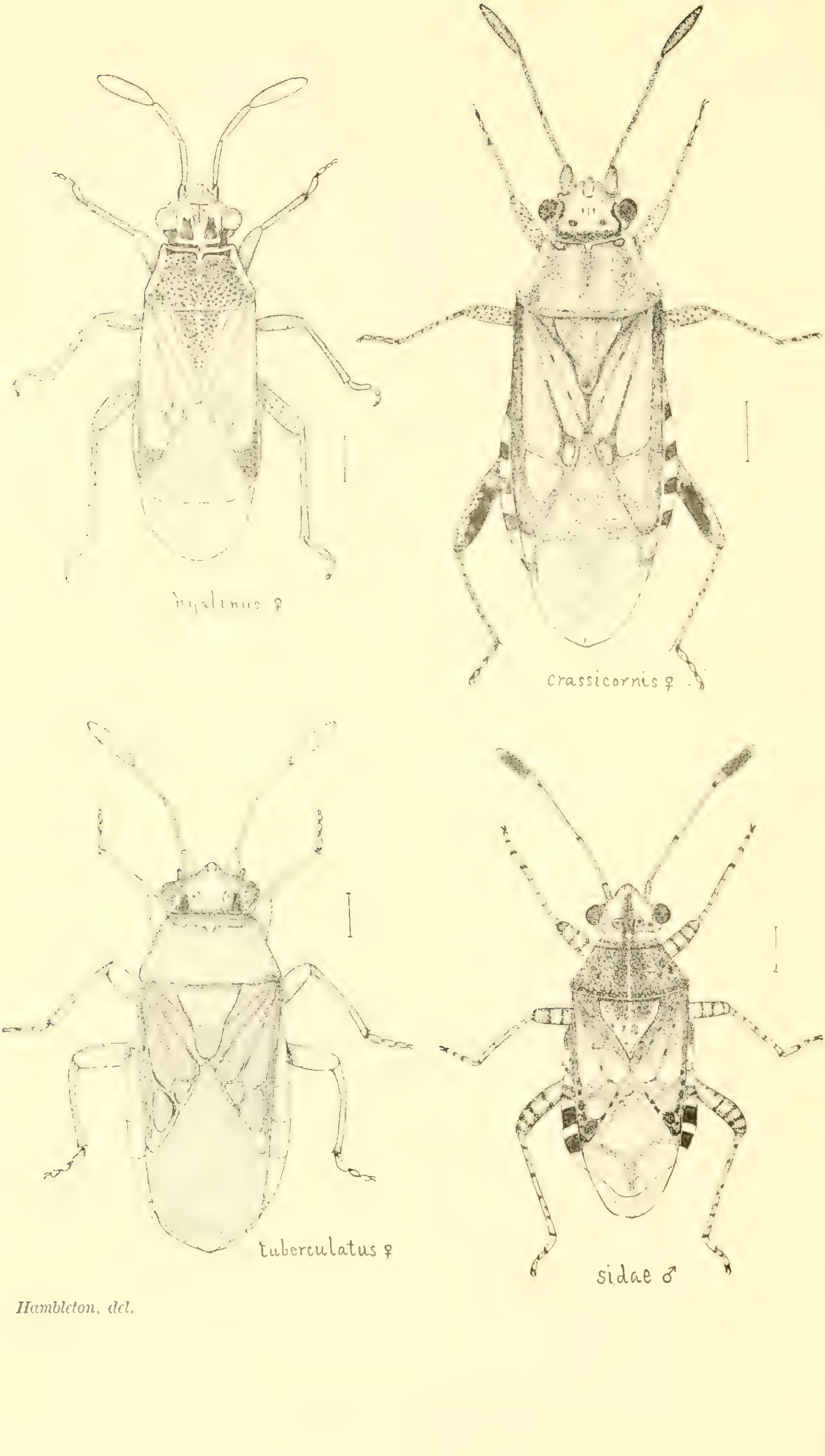
Fig. 1. Abdominal disk of hyalinus ♀
" 2. " " " crassicornis ♀
" 3. " " " viridicatus ♀
" 4. " " " scutatus ♀
" 5. " " " indentatus ♀
" 6. " " " tuberculatus ♀
" 7. " " " parvicornis ♀
" 8. " " " lateralis ♀
" 9. " " " validus ♂
" 10. " " " sidae ♀
" 11. " " " punctatus ♀
" 12. " " " nigristernum ♀

Plate X.

Fig.	1a ♂,	1b ♀,	genitalia,	side	view,	1c,	head,	1d,	scutellum of	hyalinus.
"	2a ♂,	2a ♀,	"	"	"	2c,	"	2d,	"	crassicornis.
"	3a ♂,	3b ♀,	"	"	"	3c,	"	3d,	"	viridicatus.
"	4a ♂,	4b ♀,	"	"	"	4c,	"	4d,	"	scutatus.
"	5a ♂,	5b ♀,	"	"	"	5c,	"	5d,	"	indentatus.
"	6a ♀,		"	"	"	6b,	"	6c,	"	tuberculatus.

Plate XI.

Fig.	7a ♂,	7b ♀,	genitalia,	side,	view	7c	head	7d,	scutellum of	parvicornis
"	8a ♂,	8b ♀,	"	"	"	8c,	"	8d,	"	lateralis.
"	9a ♂,	9b ♀,	"	"	"	9c,	"	9d,	"	validus.
"	10a ♂,	10b ♀,	"	"	"	10c,	"	10d,	"	sidae.
"	11a ♂,	11b ♀,	"	"	"	11c,	"	11d,	"	punctatus.
"	12a ♂,	12b ♀,	"	"	"	12c,	"	12d,	"	nigristernum.



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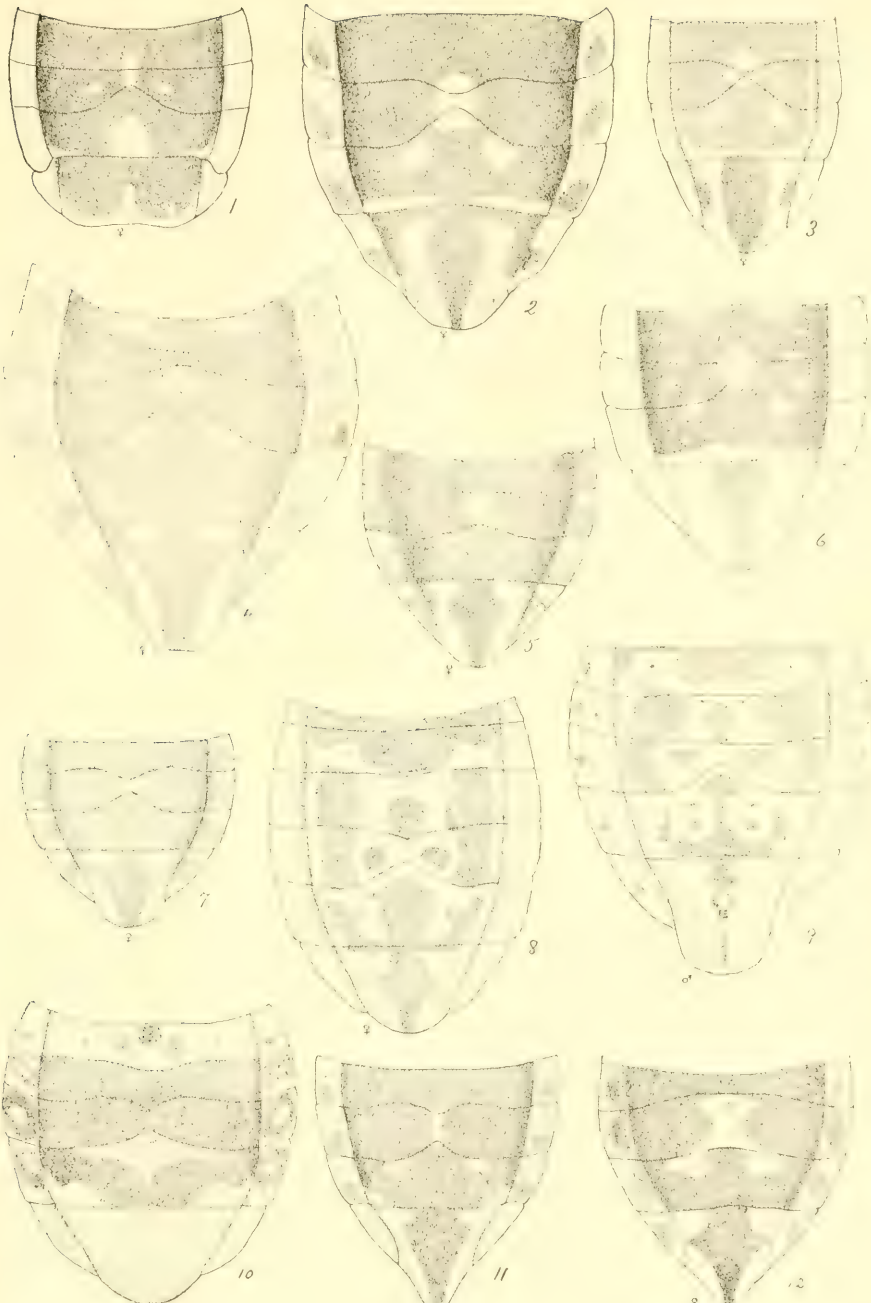

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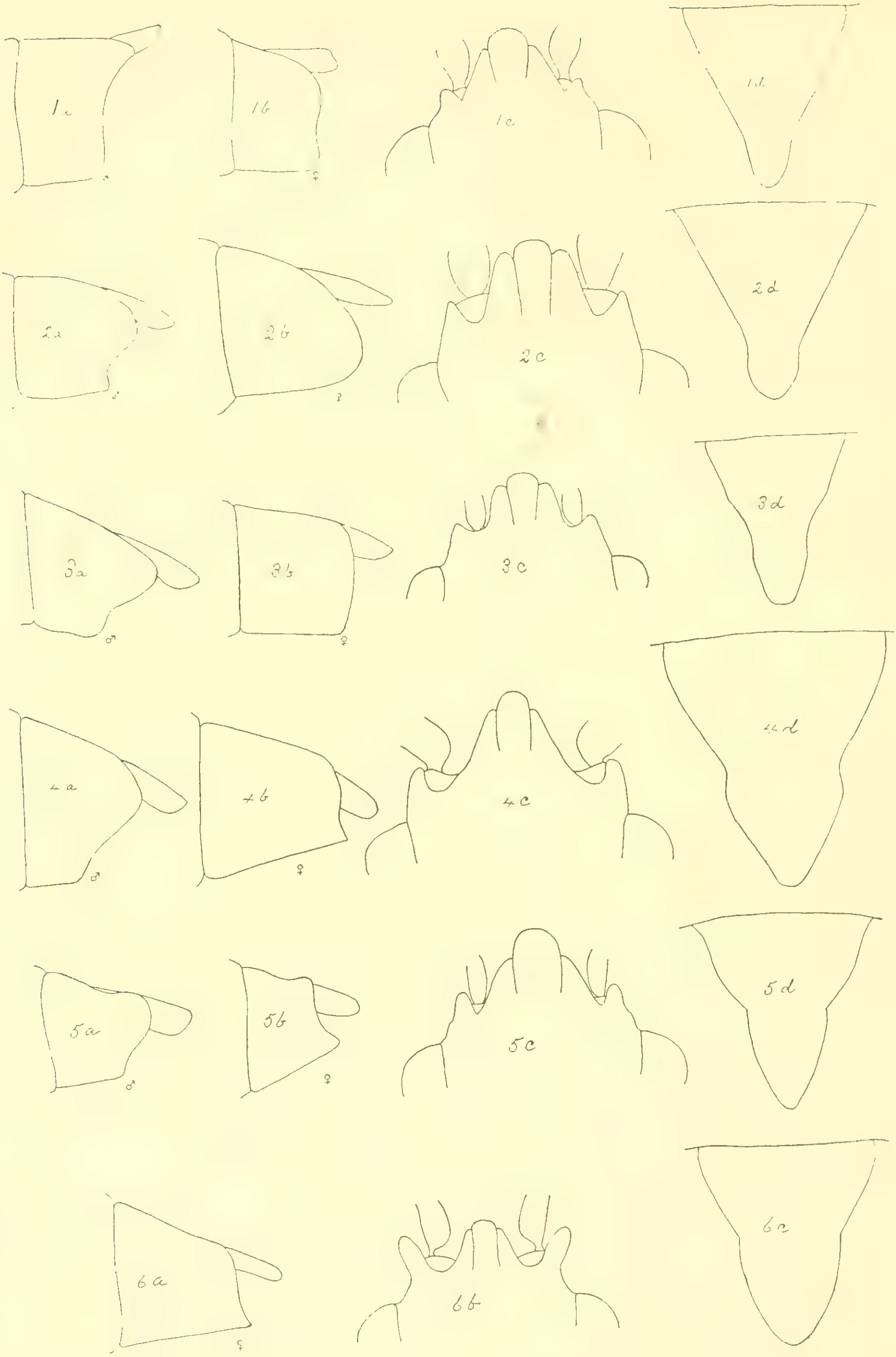

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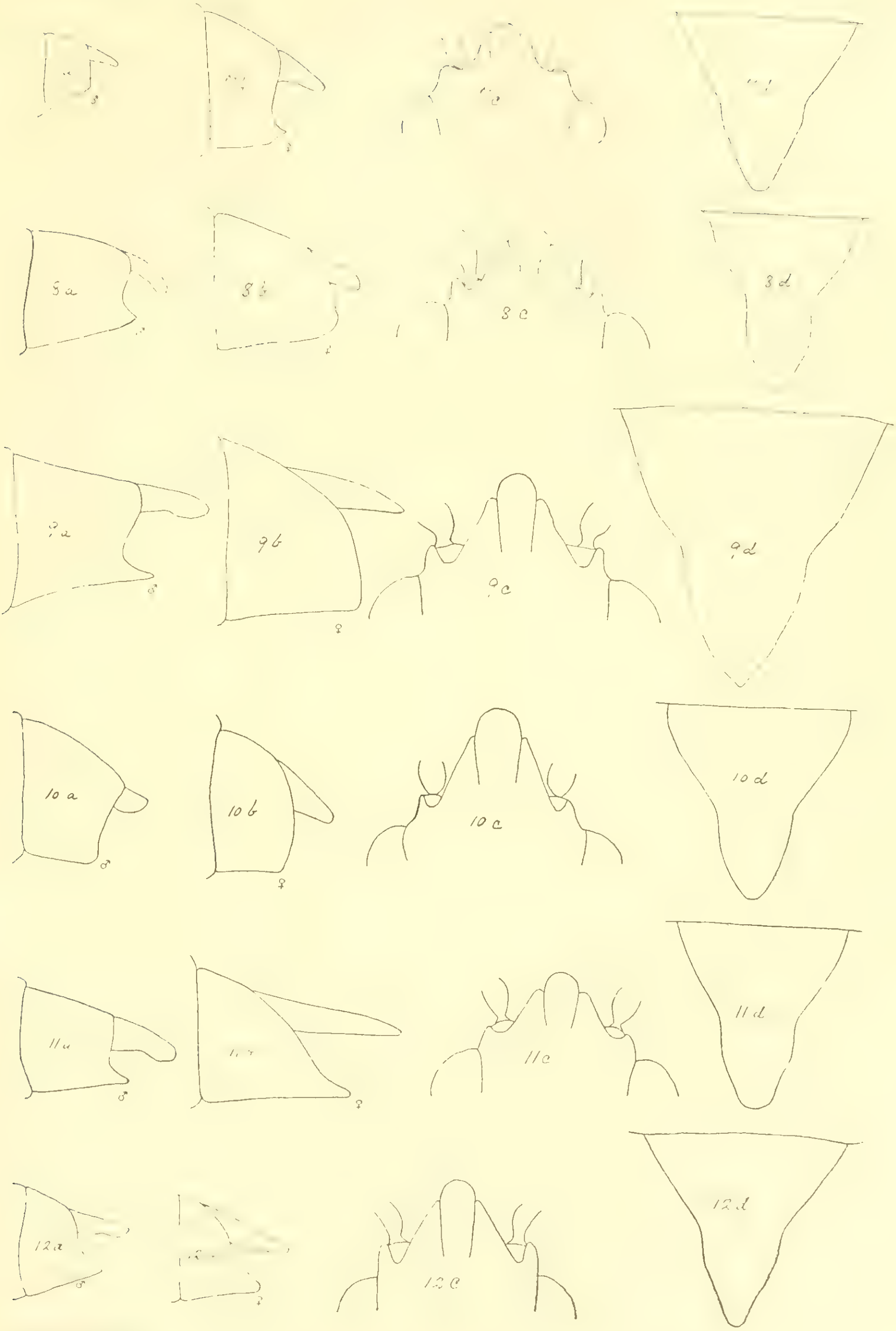

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THE ENTOMOLOGICAL SOCIETY OF AMERICA AND ITS WORK.*

By Henry H. Lyman, M. A., Montreal.

It is with considerable diffidence that I venture to address the members of the Entomological Society of America on the work of the new Society, and trust that I may not be thought guilty of presumption in so doing.

It was, naturally, a source of gratification to me that the Society, should be brought into existence under such happy auspices and secure such warm support from so large a number of the most eminent entomologists of the Continent, and I have as much reason as the able officers and Executive Committee for hoping that it will fill a useful role in the history of North American entomology. But in order that this may be so and its existence justified, several conditions are necessary.

If it were to be mainly a society of professional entomologists, it might well be questioned why it should exist in addition to the Society of Economic Entomologists, as, at least on this Continent, almost all professional entomologists are, of necessity, economic ones. It seems to me that the Society will fall short of its highest usefulness if it fails to secure the support and co-operation of the great body of amateur entomologists, and that its usefulness will be in proportion to its success in bringing amateurs and professionals into touch with each other, and in winning both to the support of its aims. But what are its aims? According to the Constitution, "It shall be the purpose of this Society to promote the science of entomology in all its branches, to secure co-operation in all measures tending to that end, and to facilitate personal intercourse between entomologists."

This is the official statement of the aims of the Society in the broadest and simplest words, but may we not with advantage elaborate them a little more. To take the last item first, viz.: "To facilitate personal intercourse between entomologists;" so far as this is accomplished, it must be productive of much good, as the better we know each other the better we should understand each other, and if we understand each other and desire to

* Read before the Society at Chicago, December 30th, 1907.

avoid causes of difference, the easier it should be to do so. Then it should be an inspiration to an amateur or beginner to know that he is a fellow member with all the most eminent entomologists of the Continent, and should be a spur to his ambition to do some good work in the science worthy of the Society.

But there must necessarily be many members, especially among the amateurs, who can hardly hope to come into personal touch with the leaders of the science through their inability to attend the meetings, and there is much danger of such members losing interest in the Society and dropping their membership, and to guard against that, I would strongly urge that we should publish something. I entirely agree with the view of the Publication Committee, that it is not desirable to take over any existing journal nor to publish anything that would occupy the field of any existing journal, or to make any of the current periodicals the official organ of the Society. The publication of a journal would hardly be feasible, unless the Society had a fixed headquarters, and that would tend too much to localize it and detract from its breadth of character. The suggestion, that we should sometime undertake the publication of a dignified series of publications in the form of "Annals" or "Memoirs," which would be distinctly creditable to American Entomology, is to be commended, but I respectfully submit that we should not wait until we are in a position to enter upon so large and important a project. Such publications, especially if well illustrated, are costly and could hardly be issued free to our members, unless the annual subscription were greatly raised, and I would, therefore, suggest, in order to keep the scattered members in touch with the movement, the issue of an annual report containing the constitution and by-laws, alphabetical list of members with their addresses, lists of fellows and honorary fellows, detailed reports of the meetings held and of the action of all committees, the President's or presiding officer's annual address, and such papers read before the Society as are not reserved by their authors for publication through some other channel, and that this report be mailed free to all members, who would thus see that they were getting something for their membership and were not forgotten.

In regard to the main objects of the Society, viz., the promotion of the science of entomology in all its branches and the securing of co-operation in all measures tending to that end, we may ask how are these ends to be attained? In the nature of

things, our general meetings must be few and far between, and coming as they do during the meetings of larger bodies, little time can be devoted to them. Under such conditions, it appears to me that the reading of papers should be only a minor part of the business at such meetings, as it makes very little difference, except for the opportunity of discussing them, whether papers are read to us or reach us through one of the many channels for publication, and might it not be well to reserve some of the time at our disposal for a general discussion on the Science of entomology and how our Society can best contribute to its advancement and be made continually more useful, as it seems to me of the highest importance that when we get a lot of prominent entomologists together, we should devote a considerable part of the time at our disposal to doing something to advance the general interests of the Science.

Might it not also be well, in view of the large membership of the Society, to remove, at least partially, the restriction limiting membership in the Executive Committee to Fellows of the Society, in order that the Committee may be enlarged and rendered more truly representative, enabling the amateurs to have better representation, and also making it possible to appoint a number of representative sub-committees for the purpose of dealing with various matters between meetings of the Society, such as the questions propounded by Dr. Felt at this meeting in regard to nomenclature, and preparing reports for presentation to the Society at its annual meeting.

Should not the Society also exert its influence against any tendency to make entomological appointments in any way dependent upon political affiliations, or upon any basis except scientific fitness for the position, and is it too much to hope that the Society may be able to do something toward bring about some approach to stability of nomenclature, either by frowning upon needless and erratic changes or by itself issuing standard lists, which would represent the combined wisdom of the many, rather than the views of an individual.

I hope that at least some of the suggestions which I have ventured to make may be thought worthy of your consideration.

FURTHER BIOLOGICAL NOTES ON THE COLORADO POTATO BEETLE, LEPTINOTARSA DECEMLINEATA (SAY), INCLUDING OBSERVATIONS ON THE NUMBER OF GENERATIONS AND LENGTH OF THE PERIOD OF OVIPOSITION.

By Alec. Arsène Girault, Washington, D. C.

During 1907 I have tried to duplicate the observations on this insect made in Georgia in 1906 (Girault and Rosenfeld, 1907), and also to extend them in length of time, and in a measure have succeeded in making some interesting and rather important ones on its life history. These observations were made during time not otherwise employed with the duties connected with a field station, and hence they are not by any means as complete and extensive as they should be and are necessarily more or less desultory; they were also started somewhat late in the season. But notwithstanding these, the facts learned I consider of importance, particularly as they tend to supplement some of the results obtained by Tower (1906), which are not very well known to entomologists. Not enough observations were made in most cases to warrant final conclusions, and with this general warning they are submitted for publication.

The observations were made in the field laboratory of the Bureau of Entomology, U. S. Department of Agriculture, at New Richmond, Clermont County, Ohio, latitude 38 degrees, 48 minutes, north.

SUMMARY.

The following paper is based on observations made during a single season on two pairs of hibernated beetles, interbred to a second generation which reproduced, contrary to the results obtained by Tower (1906) for normal beetles. A record of oviposition is given for each generation, in the case of the hibernated pairs exceeding the average recorded by Tower for normal beetles. The length of life of the adults and the period of oviposition exceeds in each instance the average recorded by the same author. In addition to observations on these points, a number of records of the duration of the egg instar for different dates are given, together with observations on habits of the larvae and adults, and a few records of the duration of the post-embryonic instars.

The paper mainly deals, however, with observations on the adult, and especially on the number of generations per season and related points concerned with the function of reproduction, and the interpretation of these observations in the light of the recent work of Tower (1906). I have, therefore, freely interspersed quotations from this work, and discussed somewhat at length the evidence so far presented in regard to the number of cycles per season, reaching the general conclusion that my observations are indeterminate in value as far as this point is concerned, mainly because of paucity; that they tend, however, to throw the question open again, especially as Tower gives but a limited amount of evidence, and that the question is entirely undecided as far as out-door conditions are concerned. I have seen no valid reason to doubt Tower's statements, excepting that the data back of them have been withheld, and that unfortunate discrepancies arise from place to place throughout.

TABLE I.—Duration of the Egg Instar, New Richmond, Ohio, Season 1907.

Remarks.*	Lot No.	No. Eggs.	Deposited. Mnoth.	Deposited. Day.	Deposited. Time.	Hatched. Month.	Hatched. Day.	Hatched. Time.	Duration. Days.	Duration. Hours.	Effective temp. Degrees Fahr. Daily Average.
	1	44	May	31	2 pm	June	10	6 am	9	16	22.42
	2	58	June	1	9 pm		11	9 am	9	12	23.62
Pair No. 1	3	62		4	9 am		12	noon	8	3	23.72
	4	52		9	10 am		15	noon	6	2	27.14
Pair No. 1	5	30		12	3 pm		18	5 pm	6	2	28.32
Pair No. 1	6	10		18	1 pm		23	5 am	4	16	33.85
	7	36		18	4 pm		23	7 am	4	15	33.85
	8	30		20	1 pm		25	5 am	4	16	34.94
	9	44		24	11 am		29	1 pm	5	2	30.70
	10	29	July	5	5 am	July	9	6 am	4	1	35.75
	11	33		7	noon		11	4 pm	4	4	37.16
	12	41		8	noon		12	10 pm	4	10	36.56
Pair No. 1	13	33		12	12:30 pm		16	11:30 pm	3	23	33.20
	14	31		19	1:30 pm		23	10:30 am	3	22	38.94
Pair No. 1, 1st generation.	15	31		23	6 pm		28	6 am	4	12	
Pair No. 1 1st generation.	16	22		28	2 pm	Aug.	2	10 am	4	20	31.94
Pair No. 1 1st generation.	17	21		29	1 pm		3	noon	4	23	32.38
Pair No. 1	18	7	Aug.	7	1 pm		11	8 pm	4	7	
Pair No. 1	19	28		13	7 pm		18	3 pm	4	20	
Pair No. 1	20	20		20	noon		25	4 am	4	16	
Lot No. 2 2nd generation.	21	39	Sept.	4	3 pm	Sept.	10	noon	5	21†	28.28†
Lot No. 1 2nd generation.	22	9		5	noon		11	6 am	5	18†	
Sums	22	710							107	281	532.77
Averages									5.40		31.34

* These refer to the hibernated pairs unless otherwise stated; and unless noted, all of these eggs are from pair No. 2 of the hibernated individuals.
† Approximated.

THE EGG.

1. *Length of Instar.* The duration of the egg instar has been determined for over seven hundred cases at different dates during the breeding season and the records are tabulated in table I. Each separate batch of eggs was confined immediately after deposition in an ordinary pasteboard pill-box, and they were thus in darkness. Moisture was supplied by the daily addition of fresh foliage. The temperature was the most apparent variable factor during development.

The effective temperatures were not determined in five cases, but enough are recorded to show that during the period covered the instar is about inversely proportional to the variation in temperature; that is to say, when the instar is long, the daily average effective temperature is low, and conversely. These records should have been made from a thermograph and calculated on the basis of hours; instead, I had to depend on maxima and minima for daily averages, and hence fractions of days had to be largely ignored. Undoubtedly, therefore, the records of effective temperatures in table I are more or less inaccurate. Forty-three degrees Fahrenheit is here assumed to mark the point of the inception of activity and reproduction, which as yet has not been determined for decemlineata. Wheeler (1889, p. 355) records the period of embryonic development as 6 days.

2. *Number of Eggs Deposited.* Our ignorance in regard to the average reproductive capability of our most common insects is profound, and this fact is well illustrated in the case of the Colorado Potato Beetle. I have simply to point out the fact that up to within the past two or three years its maximum oviposition was supposed to be in the neighborhood of 500 eggs, more probably less than that number. My observations on this point in 1907 are of importance because they show that this *estimate* is wrong, and also that with how slight an effort many of the facts of this nature can be learned more or less definitely. It was unfortunate that with the time at my disposal I was unable to make a large series of observations, thus obtaining maxima, minima, range, and average. William Lawrence Tower (1906) was the first to record actual observations on this point; apparently from a number of observations, on page 237, table 104, he records a range in oviposition of from 190 to 600 eggs, with an average of 450. The number of batches of eggs deposited ranged from 4 to 18 with an average of 12. Later (July 23, 1907,

in litt.), he states: "In regard to the number of eggs, on page 237 of my paper, you will find a table with the number of eggs laid by fifteen species of Leptinotarsa. In nature the average for decemlineata is 450—with a range of from 34 to 3700. I now have a female which has been laying eggs since April 12, and now has laid nearly 3,000 eggs. As she is in good condition, I expect to get from 3,500 to 4,000 eggs from her. This is a special race but shows the great range and the length of life of the adults. The reproductive period is in this race from 3 to 4 months long." It must not be understood from this quotation that the range of oviposition of from 34 to 3,700 as there stated is given in the place referred to (namely, Tower, 1906, p. 237, table 104), and I have since received the following from Professor Tower in regard to that statement (Tower, *in litt.*, April 21, 1908): "In regard to the number of eggs laid by Leptinotarsa decemlineata, the figures which I gave you last July were from unpublished data. The data to which you refer in my paper of 1906 are quite incomplete in regard to a lot of biological data which I did not feel like publishing at that time. There are some races of various species of Leptinotarsa which have laid eggs far in excess of 3,700, but these of course are special races. There was no mistake in giving the data. I simply gave you data which was unpublished."

Professor Tower has therefore obtained races which produce eggs far in excess of the normal beetles and which also have a much longer period of reproduction. The following account, of course, concerns normal beetles only, and so far as it goes, exceeds the averages obtained by Tower (1906) as far as reported for normal beetles.

Inasmuch as the period of oviposition and number of eggs deposited varied with the generation, the following table has been prepared showing the results obtained with the few pairs I was able to care for. Unfortunately, I was unable to keep a parallel series under field or natural conditions. This table also contains a number of observations closely connected with the function of oviposition, but difficult to present in any other form.

The table shows quite a range in oviposition according to generation, but as I have already indicated the observations are on too small a scale to allow general conclusions.

The first two pairs of hibernated adults were captured while mating in a potato field near New Richmond, Ohio, at 4 P. M., May 29, 1907, and each immediately confined in a glass jar cov-

TABLE II.—Number Eggs Deposited in Confinement by Pairs of Different Generations. Ohio. 1907.

Mating No.	Generation: Hibernated (Parents of 1st generation)				Generation: I (Parents of 2nd generation)				Generation: II (Parents of 3rd generation)			
	1st mating observed May 29, 4 p. m.				1st mating observed July 22, 10 a. m.				1st mating observed Sept. 1.			
	Pair No. 1		Pair No. 2		Pair No. 1		Pair No. 2		Lot No. 1		Lot. No. 2	
	Date	No. eggs	Date	No. eggs	Date	No. eggs	Date	No. eggs	Date	No. eggs	Date	No. eggs
1	June am 1	91	May 2 pm 31	49	July 3:30pm22	7	July 27 by pm	10	Sept. 4	6	Sept. 2	2
2	9 am 4	28	June 9 pm 1	58	6 pm 23	31			noon 5	16	3 pm 4	39
3		34	10 am 6	68	by pm 27	156			7	9	am 6	24
4	noon 5	20	10 am 9	52	2 pm 28	22						
5	11 am 6	9	11	20	1 pm 29	21						
6	pm 8	8	am 12	61	1 pm 30	28						
7	pm 9	43	14	21	pm 31	16						
8	2 pm 10	14	pm 16	17	Aug. am 3	20						
9	3 pm 12	30	am 18	17	am 3	26						
10	3 pm 15	33	4 pm 18	36	pm 4	27						
11	1 pm 17	6	pm 19	21	pm 6	17						
12	1 pm 18	10	1 pm 20	31								
13	am 19	21	21	71								
14	am 20	18	pm 22	48								
15	21	7	23	29								
16	23	41	11 am 24	44								
17	pm 24	12	26	46								
18	10 am 25	26	27	33								
19	26	31	pm 28	36								
20	27	18	July am 2	58								
21	30	6	pm 3	19								
22	July 4	15	am 5	29								
23	6	19	pm 5	26								
24	am 7	23	4 pm 6	35								
25	am 8	40	noon 7	33								
26	pm 8	16	noon 8	41								
27	By pm 11	60	am 9	18								
28	12.30 " 12	33	by pm 11	41								
29	by am 14	13	am 16	22								
30	pm 15	14	pm 18	24								
31	pm 17	28	1:30pm19	31								
32	pm 18	13	pm 20	31								
33	pm 20	48	pm 21	11								
34	pm 21	17	pm 23	12								
35	11 am 22	23										
36	pm 23	25										
37	By 27	1										
38	Aug. am 2	11										
39	am 6	14										
40	pm 6	12										
41	1 pm 7	7										
42	pm 10	23										
43	am 11	14										
44	am 13	10										
45	7 pm 13	28										
46	By4pm16	10										
47	By am 19	1										
48	noon 20	20										
49	pm 23	51										
50	2 pm 24	2										
	Total	1097	Total	1189	Total	371	Total	10	Total	31	Total	65
	Average: 1143 eggs.				Average: 190.5 eggs.				Average: 48 eggs.			
	No. batches 50 Av. per batch 21.94 Daily average 12.90		No. batches, 34 Av. per batch. 34.97 Daily average 22.01		No. batches, 11 Av. per batch 33.72 Daily average 24.73		No. batches, 1 Av. per batch 10 Dailyaverage 10		No. batches, 3 Av. per batch 10.3 Dailyaverage 10.3		No. batches, 3 Av. per batch 21.6 Dailyaverage 16.25	

ered with cheese-cloth and containing fresh soil and potato foliage. They were kept in the shade on a counter in the laboratory, and supplied fresh foliage daily. The pairs of the first generation are direct descendants of pair No. 2 of the hibernated pairs, and the two lots of the second generation are descendants of pair No. 1 of the first generation (*Vide seq.*, history of generations). These later pairs were confined in a manner similar to the first two, in the first generation, all of the individuals together until mated, and in the second generation the pairs were not separated from the whole lot.

It is clear from the table that the hibernated pairs deposited very many more eggs than did the pairs of the first generation, and in proportion, the first generation many more than did the pairs of the second. The average number of eggs deposited by each generation is given in the table; the average for the three groups of pairs is 460.5 eggs, but this has no relation with Tower's (1906) average of 450 eggs which I believe is intended as the average of any one pair in any one generation. The number of eggs and the number of batches of eggs deposited by the pairs of the hibernated individuals is the largest ever recorded for normal beetles, the latter ranging from 34 to 50, with an average of 42. Tower (1906, l. c.) records the range in batches of eggs to be from 4 to 18, with an average of 12. The average number of eggs per batch or mass ranges from 10 to 34.94 eggs, and the daily rate of oviposition from 10 to 24.73 eggs.

3. *Color of the Eggs First Deposited.* It may be mentioned in passing that the first eggs deposited by the pairs of the first generation were distinctly more reddish than usual; in pair No. 1 not becoming normally colored until the third mass was deposited (July 24th to 27th), and with Pair No. 2, the one mass of eggs deposited was of reddish hue, and the same was true of all of the eggs deposited by adults of the second generation. The coloring matter in the first eggs deposited appears to be richer, and becomes faded somewhat or less dense in the later eggs which are probably more mature before leaving the ovaries. A partial explanation of this is apparently given by Wheeler (1889). All of these eggs were fertile. On September 6th, a recently deposited mass of 29 eggs found in the field were of the same color and proved to be fertile.

THE LARVA.

1. *Length of Instars.* Observations on this point were not extended owing to the fact that it was impossible to make them continuous in time. Larvae hatching from 49 eggs (deposited at 2 P. M., May 31st, by pair No. 2 of the hibernated individuals) at 6 A. M., June 10th, molted for the first time at 9 P. M., June 15th; the time of other ecdyses not recorded. Forty-four larvae hatching at 5 A. M., June 25th, molted for the first time at 6 A. M., June 28th, and for the second time at 7 A. M., July 1, but the time of the third ecdysis was not recorded. The following table shows the only complete observation made on the duration of the larval instars.

TABLE III. DURATION OF LARVAL INSTARS FOR A SINGLE CYCLE. 1907.

Lot No.	No. larvae.	Hatched.	1st ecdysis	2nd ecdysis	3rd ecdysis	Entered soil	Sums		Total effective temperature Degrees Fahr.
			Instar I.	Instar II	Instar III	Instar IV	Days	Hours	
1	13	8 a. m. Aug. 30.	11 p. m. Sept. 1	4 p. m. Sept. 4	3 p. m. Sept. 8	5 p. m. Sept. 11			
			2 da., 15 hr.	2 da., 17 hr.	3 da., 23 hr.	3 da., 2 hr.	12	9	387.5°

2. *Number of Ecdyses.* The number of ecdyses recorded for fifty larvae during the season of 1907 was three (3), excluding pupation, and there were thus four distinct larval instars (*Vide* Girault, 1907).

3. *Length of Stage.* The duration of the larval stage was correctly determined for a few lots only; the observations on several others being interrupted at critical periods, thus destroying accuracy. The accompanying table summarizes.

TABLE IV. DURATION OF THE LARVAL STAGE FOR THREE CYCLES, 1907.

Lot No.	No. larvae.	Source.	Hatched.	Entered soil.	Duration		Average daily effective temp. degrees Fahr.
					Days	Hours	
1	30	Pair No. 2. Hibernated pairs.	5 a. m., June 25.	6 p. m., July 6.	11	13	30.8
2	21	Pair No. 1, 1st generation.	Noon, August 3.	10 a. m., Aug. 14.	10	22	32.0
3	13	Pair No. 1, Hibernated pairs.	8 a. m., Aug. 30.	5 p. m., Sept. 11.	12	9	29.8°

4. *Habits; Eating of Eggs in Nature by Young Larvae.* On September 6th, 1907, I observed a mass of 32 eggs on a potato plant in the field. These eggs were in the process of hatching, ten larvae having already excluded, and the remaining embryos being on the point of doing so. The ten very recently hatched larvae were busily making their first meals on the remaining unhatched eggs in the mass, nearly all of the perfect embryos in them having already been killed. The potato plants were in good condition, though it was rather late, and breeding was still in progress in this field; an abundance of food was at hand. This habit was previously observed in confinement (Girault and Rosenfeld, 1907, p. 53), and was then attributed to starvation. As yet it is impossible to say to what extent this occurs.

5. *Length of Life of Instar I, in Confinement without Food.* Three lots of larvae, during the second and third weeks in June, were allowed to hatch in the paste-board boxes, and then left to starve. Each lot remained together in a mass for a day or two, and then scattered and began to wander. With one or two exceptions, all of them died at about the same time. The table summarizes.

TABLE V. Length of Life in Confinement without Food, Instar I.

Lot No.	No. larvae.	Hatched.	Died.	Length Life. Days.
1.	58	9 a. m., June 11.	June 16.	5
2.	62	Noon, June 12.	June 16.	4½
3.	52	Noon, June 15.	6 a. m., June 20.	4¾
Sums	172			14.25
Averages				4.75

THE PUPA.

1. *Duration of Stage.* The few observations recorded on this point are briefly tabulated as follows:

TABLE VI. Duration of Pupal Stage, Actual Time in Soil, Different Dates. 1907.

Lot No.	No. pupae	Entered soil.	Adults emerged.	Length of time in soil.	Sums of effective temperatures, deg. Fahr.
1	40	6 p.m., July 6	12:30 p.m. July 17	10 das., 18½ hrs.	391.3°=35.5° daily average.
2	15	10 a. m., Aug. 14	10 p.m., Aug. 27*	13 das., 12 hrs.	†
3	11	5 p. m., Sep. 11	10 a. m., Sep. 25	13 das., 17 hrs.	†

* Average time: 4 at 10 a. m., Aug. 26th; 7 at 10 a. m., Aug. 27th, and 3 at 7 to 10 a. m., Aug. 29.
† Hiatus in records.

THE ADULT.

1. *Length of Life in Confinement.*

a. In pairs normally reproducing. The results obtained on this point are important, indicating as they do a very much longer adult life than formerly believed, and even going beyond the records of Tower (1906, p. 231, table 103). With Tower in normally reproducing adults, over 88 per cent. had died by the twenty-fifth day, 67 per cent. by the twentieth day. My experiments were necessarily on a much smaller scale, yet all of the pairs kept by me, and in fact all of the adults recorded in following, confined together, lived considerably over the periods recorded by Tower. For instance, the hibernated pairs of the wintering generation, captured mating at 4 P. M., May 29th, and at once confined and supplied daily with food, reproduced continuously and did not commence to die until after the middle of the following August; the male of Pair No. 2 died on August 16th, the female of Pair No. 1 on August 28th, after not quite three months, the female of Pair No. 2, not until October 6th, much over four months after capture and the male of Pair No. 1 did not die until April 6, 1908, after it had been in hibernation since July 2, 1907, emerging on February 26, 1908.

As Tower points out (1906, l. c.), these records may be due to exceptionally long-lived individuals. Table VII summarizes.

TABLE VII. LENGTH OF ADULT LIFE IN CONFINEMENT, NORMALLY REPRODUCING.

Lot No.	No. individuals		Source.	Date confined, 1907.	Date of death, 1907.		Length of life, months.	
	Male	Female		Emergence	Male.	Female.	Male.	Female
I. Hiber. 1 2.	1 1	1 1	Potato field	4 p. m., May 29	1. Ap. 6, 08. 2. 5 p. m., Aug. 16	1. Aug. 28 2. Oct. 6.	10+ 2.6	3± 4.25
II. Gen.1 1 2	1 1	1 1	Pair No. 2 hibernated	12:30 p. m. July 17.	Hibernated, Nov. 1.	Hibernated, Nov. 1.	3.5(+?)	3.5(+?)
III.Gen.2 1 2	9 4		Pair No. 1 gen. No. 1	Aug.26-27	Hibernated Nov. 1.	Hibernated Nov. 1.	2.2(+?)	2.2(+?)

b. Mixed sexes, without food. A single lot of adults, survivals of 30 larvae hatching at 5 A. M., June 25th, and produced by Pair No. 2 of the hibernated individuals, and emerging from the soil in a large glass jar at 12:30 P. M., July 17th, were immediately fed and kept supplied with food until mating began on

July 22nd, when two mated pairs were removed to comprise the pairs of the first generation. The remaining 7 beetles of both sexes were fed until 10 A. M., July 27th, and then left to starve, and the soil in the jar allowed to become hard and dry. On the morning of August 11th, drops of water were added to the soil, and some of the adults drank of it; two of the beetles were then buried just below the surface of the earth. Nearly two months later, September 20th, three of the beetles died, and were found lying on the surface of the soil, which was now hard and caked, though it had been moistened from time to time. On September 25th, one adult was alive on the surface of the soil and the other three were exhumed alive; the soil was then dry and compact, but was again moistened from above on that date. The exhumed beetles again entered the soil; the one remaining above died on October 3rd. On October 17th, the three adults remaining were again exhumed alive and replaced on top of the soil, which they soon re-entered. Finally on November 1st, they were carefully examined and found in apparently good condition. They were placed on fresh, sifted soil, together with the male of Pair No. 1 of the hibernating individuals, allowed to enter it, and the jar containing them was placed in a place suitable for hibernation. They finally emerged on February 26 (1), April 7 (1) and April 11 (1), 1908, and are alive today (April 30, 1908).

Summarizing, the 7 beetles of mixed sexes lived as follows, after feeding was discontinued: 3 lived from July 27th to September 20th, or 55 days; 1 lived from July 27th to October 3rd, or 68 days; the remaining three lived at least until April 30, 1908, or over.

It is to be remarked that no reproduction occurred after food was discontinued, though a few eggs were deposited on July 23rd, during the period of feeding. As is to be expected none of the adults were observed mating either.

2. *Length of the Period of Oviposition.* By consulting table II, in which is given the number of eggs deposited by pairs of different generations in 1907, it is seen that the period of oviposition varied considerably for each generation, and was very much the longest for the pairs of the hibernated individuals. The table below makes the differences more apparent.

The period had a range of from 3 to 85 days, according to generation. Tower (1906, p. 237, table 104) gives the average

length of this period for normal beetles as 30 days*, but these figures are given on the supposition that there are but two generations which reproduce, the hibernated generation and the first generation (Ib, p. 243). An average of 32 days for the period of oviposition is obtained for the three generations, providing that Pair No. 2 of generation I is ignored, there having been no amount of reproduction with this pair. I should think it fairer, however, to consider averages for each generation, as the conditions are different with each, and especially so with the hibernated pairs which have a decided advantage in regard to available time for reproduction. It is apparent from previous tables that the period of oviposition is not directly dependent upon the length of life of the adults; that is to say, the latter may be much greater than the former which does not necessarily close with the death of the female. The reproductive periods appear to be more directly dependent upon the available food supply, the season of growth of the food plant, and similar factors, and I believe the short periods of the later generations may be thus explained, a view in direct conflict with Tower's (1906) limiting physiological principle.

TABLE VIII. Length of the Period of Oviposition, Different Generations, 1907.

Generation No.	First mated.	First eggs Deposited.	Last eggs Deposited.	Length period of oviposition. days.
Hibernated—				
Pair No. 1	May 29, p. m.	a. m., June 1	2 p. m., Aug. 24	85
Pair No. 2		2 p. m., May 31	p. m., July 23	54
I.				
Pair No. 1	July 22, a. m.	3:30p.m.July 22	p. m., Aug. 6	15
Pair No. 2		By p.m., July 27	July 27	1±
II				
Lot No. 1	Sept. 1	Sept. 4	Sept. 7	3
Lot No. 2		Sept. 2	Sept. 6	4

3. *Mating.* With each generation, I have recorded the number of times which I have observed mating, but undoubtedly this act took place with more frequency than the records indicate, as I was unable to watch the pairs continuously, either during the day or night, and they are by no means complete. I tabulate these observations for convenience.

Pairs were observed mating twice on the same day (Pair No. 2, hibernated individuals), usually once in the morning and once

* For special races, however, as shown by the quotations from correspondence in foregoing, the period was much longer.

in the afternoon, but on July 6, twice in the afternoon; mating was observed at the following hours of the day: 3 P. M. (May 31); noon (July 15); 4 P. M. (May 29, July 21); 2 P. M. (June 5, Aug. 6); 10 A. M. (July 22); 11:30 A. M. (July 22); 11 A. M. (July 24); 4 P. M. (Sept. 5); 7 P. M. (Sept. 5); the observations seem to show that mating occurs as frequently in the morning as in the afternoon. The table also shows the relations between mating days and period of mating to period of oviposition and number of egg-masses deposited.

TABLE IX. FREQUENCY OF MATING IN REPRODUCING PAIRS, DIFFERENT GENERATIONS, 1907.

Generation No.	Pair No.	First mating	Subsequent matings.	Last mating	No. of matings	Observed period of mating, days.	Period of oviposition, days.	No. egg masses deposited.
Hibernated.	1	4 p. m. May 29	May 31. June 2,3,4,5,8,9,16, 17,18,20,23,24.	June 28*	15	May 29– June 28 30 days.	85	50
	2	4 p. m., May 29	May 31. June 3,10,12,13,17, 19,20,22,24,25,28, 29. July 1,3,3,4,4,5,6,6, 9,15,18,19,21.	Aug. 6†	28	May 29– Aug. 6, 69 days.	54	34
I.	1	10 a. m., July 22.		p. m., August 1‡.	2	July 22– Aug. 1. 10 da.	15	11
	2	11:30 a. m., July 22	July 24, 30, 31	Aug. 6•	5	July 22– Aug. 6, 15 da.	1±	1
II.	Lot 1	Not observed					3	3
	Lot 2	Sept. 1, approx.	4. p. m., Sept. 5	Sept 8°	3	Sept. 1– Sept. 8. 7 das.	4	3

* Male entered earth, July 2. † Male died, August 16. ‡ Male entered earth, p. m., Aug. 5th.
• Male entered earth, a. m., August 7th. ° Began to hibernate, Sept 7th.

4. *Potency of Fertilization.* No experiments were made to test this directly, but in the case of Pair No. 1 of the hibernated beetles some data have been obtained on it. Although the male left his mate on July 2nd and buried himself into the soil, the female continued to produce eggs until 2 P. M., August 24th, less than four days before her death, and 52 1-2 days after having been deserted by the male. During these 52 1-2 days, she deposited no less than 591 eggs or more than half of the total number deposited by her during the season; these eggs were deposited in 29 separate masses ranging from 1 to 60 eggs and averaging 20.3 eggs per mass; the daily rate of deposition for this mateless period was about 11.2 eggs. The eggs were tested for fertility at frequent intervals with positive results, and up until P. M.,

August 23rd, on the next to the last mass of 51 eggs. As compared to the period during which the male was present, a period of 34 days, 506 eggs were deposited in 21 masses ranging from 6 to 91 eggs and averaging about 24 eggs per mass, and with a daily rate of deposition of about 14.9 eggs; there is apparently some difference, as the daily rate of deposition fell after the male left, though his absence did not seem to matter very much. However, it is idle to speculate about a single observation of this kind. The simple fact is that the female continued to deposit fertile ova for many days after the male left.

It is well to note in this connection, the fact that oviposition in Pair No. 2 of the hibernated beetles stopped quite early, on July 23rd, 24 days before the death of the male and 74 days before that of the female; the female of this pair therefore lived for fifty days after the death of the male but deposited no eggs. I fail to account for the lack of production during this period, and merely mention the fact in order to show the singular difference in behavior between the two pairs. In Pair No. 1 of the first generation, both sexes disappeared beneath the soil at the same time, whereas in Pair No. 2 of the same generation, the male entered the soil fifteen days before the female, but again no deposition occurred after his desertion, and in this case but very little before.

5. *Number and History of Generations Reared in the Laboratory.* At 4 P. M., May 29th, 1907, as previously stated, two normal pairs of this insect were captured *in copula* in a potato field a quarter of a mile west of New Richmond, Ohio, and these were at once brought to the laboratory and confined, each pair separately, in a suitable glass jar containing moist soil and covered with cheese-cloth. They were kept constantly supplied with fresh potato foliage and soon began to produce a continuous series of eggs as shown in table II. These pairs were evidently hibernated individuals and they constituted the parents of the first generation.

Eleven adults emerging from the soil at 12:30 P. M., July 17th, being descendants of Pair No. 2 of the hibernated individuals (*cf.* table X) were confined together with food on that date, and on July 22nd, two of the pairs observed mating at 10 and 11:30 A. M., respectively, were transferred to separate jars; these constituted the parents of the second generation. Pair No. 1 of these two (*cf.* tables I and II) deposited 21 eggs which hatched at

noon, August 3rd, the resulting thirteen adults emerging from the soil at 10 A. M., August 26th and 27th, and constituting the parents of the third generation, which unfortunately was not carried through to the adult stage, though larvae were obtained from the 96 eggs deposited by them. The following schema and table represents graphically these generations reared in confinement. Other relative data are given in connection with a preceding table (table II).

SCHEMA OF GENERATIONS REARED IN THE LABORATORY, NEW RICHMOND, OHIO, 1907.

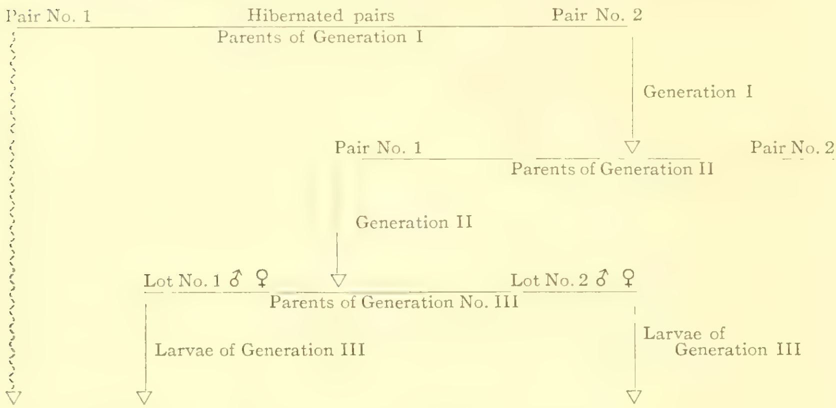


TABLE X. GENERATIONS REARED IN THE LABORATORY, NEW RICHMOND, OHIO, 1907.

Generation No.	Eggs deposited.	Adults out.	Length of cycle. Days.	Length of cycle. Hours.	Effective temperature, sum.
I.	1 p. m., June 20th.	12:30 p. m., July 17.	26	23½	897.2° Fahr.
II.	1 p. m., July 29.	10 p. m., Aug. 26.	28	9	*
III.	Sept. 2–4.	Not reared to maturity.			

* Not obtained.

It is interesting to note in connection with the third generation, that although in itself not reared to maturity on account of the lack of opportunity, yet an almost parallel cycle was obtained from a series of 13 larvae hatching at 8 A. M., August 30th, from eggs deposited by Pair No. 1, hibernated individuals or parents of the first generation, and coming to maturity at 10 A. M., September 25th; this generation of larvae was not more than four or five days earlier than the third generation. There can be no doubt that the parents of the third generation (or the adults of the second generation) were willing to reproduce to some extent

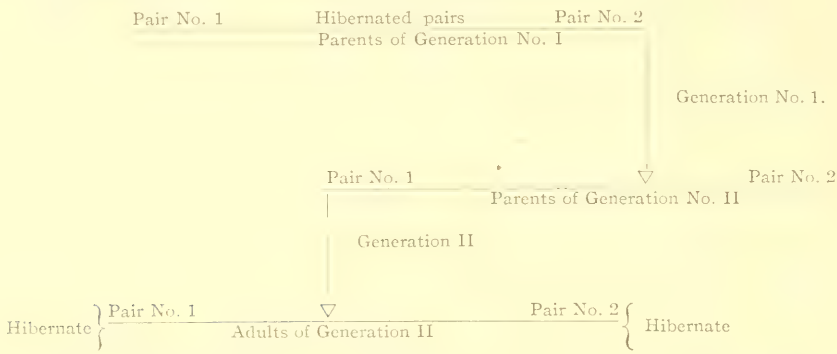
before going into hibernation, and there appears to be no reason why the larvae so produced should not have reached maturity with ease. It seems perfectly reasonable to me to have reared at least three, if not four, complete cycles of this insect during the season, if the breeding had been started about the first of June, instead of more than three weeks later, as unfortunately was the case.

Although the foregoing looks clear enough to me, but because of the conditions being those of confinement and on so small a scale, I approach with caution the statements of Tower (1906, p. 243), on the number of generations in Leptinotarsa decemlineata. Quoting directly from this work, he says: "The number of generations in Leptinotarsa each year, in both temperate and tropical latitudes, is a remarkably constant character, and might well be used as a generic differential. As far as I know, the number in all of the species is limited to two. Thus, there are two generations throughout the range of decemlineata, although Lugger has recorded three in Minnesota, and others have supposed that there may be three in the southern United States. I have not, however, been able to get decemlineata to breed more than twice in a season without a period of hibernation or aestivation. In the spring decemlineata emerges from the ground, and after a period of feeding, during which the germ-cells are also maturing, it breeds and lays the eggs for the first generation. These are usually all deposited at about the same time, but there are always for a month or more some individuals that are laying eggs, and of course the larvae and imagines resulting from these eggs which are last laid are much later in maturing than are the majority of the population. The first brood, on emergence, feeds for a few days, and then deposits the eggs for the second generation. The majority of these eggs hatch late in the summer, and after the animals feed and fly around for a month or more they burrow into the ground, and there hibernate until the following spring. The second generation does not develop the germ-cells nor show any reproductive activity until after it has passed through a period of hibernation or aestivation. Beetles are found breeding even late in the autumn, but these are the belated individuals of either the first or second generation. As far as I can discover, the life cycle in this species is that given above." Further down on the same page, he says: "The species in the genus are therefore double-brooded, the second brood undergoing hibernation or aestivation before reproductive activity is re-

sumed." And again on page 244: "In all the species of the genus the only difference between the two generations is that the second does not develop the germ-cells until after a period of rest, while the other develops them at once, or soon after emergence."

Although these statements are not very clear to my mind, because of certain ambiguities*, yet the following schema represents my interpretation of Tower. This schema, for the convenience of comparison with the one in foregoing (p. 168), is based on two pairs for each generation.

SCHEMA REPRESENTING AN INTERPRETATION OF TOWER'S GENERATIONS OF DECEMLINEATA.



By comparing the two schemata, it is at once apparent that a portion of a third generation is represented by my observations, and this is clearly in disagreement with the reiterated statements of Tower, to the effect that the adults of the second generation do not breed, or even show signs of breeding, before a period of hibernation or aestivation. This fact would not be considered of much importance, owing to the laboratory conditions and meagreness of the observations, were it not for the statement made by Tower (*Ib.*, p. 246) that "In decemlineata I have not by any process been able to prevent this preparation for hibernation in beetles which should normally hibernate." The mating and reproduction of the adults of the second generation are therefore very,

* For example, the two successive sentences on page 243: "The *second generation does not develop the germ-cells nor show any reproductive activtiy until after it has passed through a period of hibernation or aestivation.*" and "Beetles are found *breeding* even late in the autumn, but these are the belated individuals of either the first or *second* generation." It is clearly implied in the last sentence that beetles of the second generation breed, which flatly contradicts the declaration of the first; there exists a confusion of terms both here and elsewhere in the discussion. The italics here are mine.

very exceptional, according to Tower, for it is implied that he was unable to find such either under a great variety of natural habitats, or under all possible laboratory and experimental conditions. Hence it seems all the more strange that these phenomena should occur from the first under ordinary laboratory conditions, in a breeding experiment which was purely incidental.

But Tower does not give all of the matter concerning this question together, and it is in the later portion of his work that we find the most pertinent data on it. This is in relation to the production of special races by breeding under controlled conditions.

If a race can be considered the same as its species, Tower practically admits that there *may be* on occasion, more than two annual generations, and thus contradicts himself, for he says on page 251: "Closely associated with the hibernation of the second generation in these beetles is the quiescent or resting period in the cycle of the germ plasm. That is, the germ cells do not develop at all in the autumn, but remain as oocytes or spermatocytes, which are relatively few in number, until the following spring after emergence from hibernation, when they develop rapidly. This period of inactivity in the reproductive elements has been regarded as due to some inherent necessity for rest in the germ plasm. However, it does not seem to me to be of this nature; it is rather in the nature of a very deep-seated adaptation, like aestivation, which has been developed and retained not only in this genus, but also in the whole insect phylum, for the purpose of enabling them to pass successfully over the season of the year when unfavorable conditions of existence are most apt to occur. In my experiments a race arose suddenly in which there were five generations, and then a period of rest, and then five more, and so on." From this quotation, it is apparent that Tower obtained five seasonal generations with what he calls a *race* of the *species* decemlineata. I believe, however, that the distinction is justifiable because the appearance of the individuals with five annual cycles, under controlled conditions in confinement, was relatively scarce, abnormal, and they had racial characteristics.

Again, Tower (*Ib.*, pp. 280–281) gives another illustration of the occurrence of more than two annual cycles: "A variation which arose from decemlineata obtained at McPherson, Kansas, appeared in my culture in June, 1904. This was rubrivittata,

of striking form and coloration, of which there was a single male. The parents, which were collected in July, 1903, near McPherson, Kansas, were sent to Chicago and reared in a second generation which was normal; they hibernated until May, 1904, and then emerged, reproduced, and among the progeny was this single male rubrivittata. This male was crossed with a female decemlineata from Chicago, and gave a hybrid brood intermediate in character between the parents. Three males and one female of this lot escaped the general extermination of my experiments in July, and were carried over into 1905, giving after transfer to Mexico in March, 1905, a Mendelian splitting into typical rubrivittata and hybrid forms (text—fig. 22). These were separated and reared. The pure cultures of rubrivittata showed as a result a new character, namely, that its life-history as well as less important characters were changed, there being three generations in its yearly cycle instead of two, as in the parent species, and in all of the species in its immediate ancestry.

"This change in the life cycle from hibernating in every second generation, as do most of the species in the genus, to hibernating in every third, is striking and significant, the three generations being gone through in about the same time as the two of the parent species. The cultures with rubrivittata demonstrate clearly that *changes in physiological characters can take place rapidly, as do changes in structure*, and that these changes may alter not only unimportant characters, but most fundamental ones as well. We shall have occasion to consider a similar case even more striking and interesting in a later portion of this chapter."

The remaining case referred to in the last sentence of the quotation just ended (from pp. 280–281) is now given for convenience and in order to place all of them as near together as possible; space does not allow of its being given in full, and I give a brief history of it until the variation appears. Beetles emerging from hibernation in May, 1901, (Tower, Ib., p. 288) were reared until May, 1902, under normal conditions without extreme variation. They were then divided into two lots and subjected, one to hot and dry conditions, and the other to hot, dry and low pressure conditions. The first is considered.*

"From the apparently pure stock, 7 males and 7 females were in May, 1902, subjected during the first half of their reproductive

*The other lot appears to have been ignored, though a statement is made to contrary (p. 288).

period to hot, dry conditions, during which time they laid 409 eggs. For the latter half of the reproductive cycle they were kept in normal conditions, laying 840 eggs, From the 409 eggs developed and laid in changed surroundings I obtained 64 adults, as follows:

"A(1) Normal (apparently) decemlineata, 12 males, 8 females; (A 2) L.pallida, † 10 males, 13 females; (A 3) L. immaculothorax,* 2 males, 3 females; and (A 4) L. albida,† 9 males, 7 females. These four lots were separated and reared, with the exception of pallida. The 840 eggs laid in normal conditions gave 123 normal decemlineata, and these I designated B.

"The Lots A1 and B were reared side by side in the following generations and both gave normal beetles as far as could be determined, but as the period for hibernation approached, those of A1, instead of going deep into the ground, as did B and as is normal, aestivated on top or close to the top. The Lot B went into hibernation in September, A 1 in late October and early November. In January (January 2) Lot A 1 emerged from aestivation and began breeding, giving a brood, part of which hibernated and part continued breeding for five generations, then hibernated, and then emerged and bred through five more generations. These hibernated again, and in the fourth generation of the third cycle of five generations were killed in July, 1904. These successive generations were all reared under exactly similar conditions, nor‡ was there any conscious selection practiced. Free interbreeding in each lot was allowed. The general result is expressed in text-figure 26.

"This race with a cycle of five generations is of great interest, showing the profound modification resulting in the reproductive cycle. None of the beetles of the lineata group, to which this beetle belongs, have more than two, or rarely three generations per year, and there are none known in the genus that have over three. Clearly, then, this race with five generations in each cycle is quite a new character in the genus, and was, as far as discovered, constant|| from the start, showing in the fourteen generations no tendency to revert to the parental standard. As far as I can discover, this case can be explained only as the direct response of the germ plasm to the extreme stimuli used in the experiment.

* L. decemlineata pallida Tower; L. decemlineata immaculothorax Tower.
† L. decemlineata albida Tower. (Cf. p. 92).
‡ Beginning p, 289.
|| Beginning p. 290.

It seems impossible to account for the condition produced upon the basis of a latent character of this kind somewhere in the ancestry of this genus. Moreover, all of the beetles in this experiment had an equal chance to be accelerated by the conditions of existence, so that this factor could not by any stretch of the imagination be held to account for the development of this change. As far as is known, the only changed factor in this experiment was that used in the third generation upon the 7 males and 7 females for three-fifths * of the reproduction period†. From the germ cells subjected to stimuli this race arose, but not at once, two generations being necessary in which to disentangle the changed character from the non-modified decemlineata."

Therefore, in order to agree with Tower's results, the production of eggs by the adults of the second generation of the beetles reared by me in 1907, will have to be considered as due to some abnormal stimulus present during maturization of the reproductive elements, or as a racial characteristic; but it seems to me that either supposition is improbable, because of the few generations through which the beetles had been inbred. Tower's evidence is poorly presented, without reservation or limitation in places, it is contradictory and it is to be regretted that in a great many places he has contented himself with giving general statements without the accompanying data as evidence; conditions that produce controversy instead of establishing fact. When his evidence is sifted, however, it is found that the following facts are indicated as being true:

1. That decemlineata, when bred in confinement in normal environments, in all cases goes through but two annual cycles the second of which hibernates before reproduction.
2. That decemlineata, when bred in confinement through more than three generations in abnormal controlled environments, in the great majority of cases goes through but two annual cycles, as in normal beetles.
3. That the species, when bred in confinement for more than three generations in abnormal controlled environments, exceptionally may go through as many as five annual cycles, this physiological variation being correlated with morphological variations of racial value, produced suddenly.

* One-half? (Cf. Statement of conditions, p. 288).
† A foot-note follows here, which is omitted in the quotation.

These being true, the facts recorded by me in regard to the production of a third generation are indeterminate in value, and exceptional in nature, for apparently there were neither abnormal environmental factors present, nor variation tending to racial evolution. It would be highly interesting and important, therefore, if more of this breeding of annual cycles under normal or natural conditions, was carried on, in two similar series, in the laboratory and in the field under as natural conditions as possible. The question of the number of annual generations of decemlineata freely breeding in nature has not been determined yet by actual experiment, or at least such are not recorded with cold evidence, and Tower (1906) has not decided it, but perhaps left it in a more controversial position than ever; he has, however, made a long stride in the direction of settlement.

But looking at it from another standpoint, I believe that Tower (1906), although in the proper place (Ib., Chapter IV, p. 243) not presenting definite data upon which his conclusions are based, has the best right to be followed because of his large experience with breeding the species in question. As I understand it, he speaks of normal, average conditions in nature, and I do not know that any direct or definite evidence has yet been presented to show that the species is more or less than double-brooded in nature, and Tower certainly has had enough experience with decemlineata in nature to speak with authority on the subject. There are certainly as many as two annual cycles, if repeated laboratory experiments can be at all trusted, and Knab's (1908) recent contention that there is but one, based on the systematic relations of the beetle is not tenable, and to my belief, wholly without basis or foundation for advancement. The question now is: Are there but two, or more than two annual cycles with decemlineata; or, in other words, does the second generation reproduce? This does not concern any other species of Leptinotarsa or species of Calligrapha, Lina or Gastroidea, but the sole species under consideration.

I have myself recorded reproduction by a first reared generation of Gastroidea cyanea Melsheimer (Girault, 1908, p. 8), making two annual cycles possible, but I can't see what the number of generations in closely related genera of the family has to do with the question at issue, especially since the question with these genera is not established. It was also going beyond the point to say that the seeming double-broodedness of decemlineata "may

be due to the difference in time of emergence from hibernation of different individuals," for Tower (1906, pp. 202, 266–267, *et al.*) gives evidence by direct breeding, thus throwing this out of the question.

And summing up, all of this discussion but again calls attention to the crying need for facts. We want tangible evidence, not inductions, views, opinions, or claims.

6. *Behavior of Adults in Confinement; Hibernation.* The pairs kept in confinement, normally reproducing, behaved in some instances peculiarly; this was especially noticeable in the case of the male of one of the hibernated pairs. In pair No. 1 of the hibernated beetles, the two sexes behaved normally until on July 2nd, the male disappeared and was found on the morning of July 3rd buried beneath the soil; it was replaced on the surface but again went beneath after several hours had elapsed. It was exhumed again at 3 P. M., July 6th, and was again beneath within the following hour, and the same fact holds for 10 A. M., July 9th. It was re-exhumed at 5 P. M., July 15th; 3 P. M., August 5th; August 19th (A. M.); 11 A. M., August 28th, September 2nd, October 17th and 23rd, each time re-entering at once and paying no attention to the female or food. On November 1st, it was again disturbed and given fresh quarters for hibernation; it finally emerged (it was kept in a cold room) on February 26th, 1908, and died on the following April 6th; it had apparently hibernated during two winters, that of 1906–1907 and 1907–1908.

The male of pair No. 2 of the hibernated pairs behaved normally until its death at 5 P. M., August 16th. The male of pair No. 1 of the first generation entered the soil P. M., August 5th, and the female P. M., August 7th; both were exhumed alive at 10 A. M., August 19th and replaced on the surface with fresh food which they ignored and re-entered the soil. They were exhumed alive on November 1st and liberated. The male of pair No. 2 of this generation entered the soil A. M., August 7th and was exhumed at 10 A. M., August 19th; it at once re-entered. On August 22nd, the female of this pair entered the soil, and at 10 A. M., September 2nd, both were exhumed alive and replaced on the surface of the soil into which they soon disappeared. On October 17th and 23rd, the exhumation was repeated with similar results; they were dug up alive and liberated on November 1st, 1907, with the other pair. In Lot No. 1 of the second generation, 2 entered the earth on September 7th, and on the 9th of the same month

the remaining beetles entered (between the two dates, their food had of necessity been neglected and had wilted); on October 17th the seven were exhumed alive and placed on the surface of the soil into which they had disappeared within an hour. They were exhumed alive and liberated with the others on November 1st. The adults of lot No. 2 of this generation entered the soil together on September 12th, and were undisturbed until liberated on November 1st, all in good health and hibernating.

Even when entering the conditions of hibernation in the warm summer months, it seems almost impossible to break into the habit and induce the beetles to feed or mate. Their physiological condition must be profoundly modified in this state, as has been found to be the case by Tower (1906, p. 245ff.)

General Field Conditions, Supplementing the foregoing.

I was unable to watch the beetles in the field at all closely, so that but a few fragmentary observations were made; these will serve, however, to give some idea of the general conditions prevailing with the species in the late summer of 1907. It should first be stated that the season of 1907 was very abnormal, in that the spring was at first far advanced in March, it then being very warm, and later in April retarded by a cold wave which killed young plants and newly set fruit or the far advanced fruit buds; planting was therefore much delayed in many cases, but data kindly gathered for me by the Reverend Mr. C. L. Chapman of New Richmond, showed that the potato crop was at least an exception. The following table compiled by Mr. Chapman shows the relative times of planting and harvesting of the potato crop in the vicinity of New Richmond, Ohio, for the three seasons past.

TABLE XI. Relative Times of Planting and Harvesting Potato, 1905–1907.

Year.	Preparation of Soil.	Time of General Planting.	Time of Harvest.
1905.	March 27–April 20.	March 30–April 30.	September 1–October 1.
1906.	April 1–April 20.	April 13–20	July 20–August 31.
1907.	March 25–April 15.	March 29–April 20.	September 30–October 10.

From the table, it appears that the crop remained in the field somewhat later than usual in 1907, and this would apparently have some bearing on the breeding of the beetles.

On September 2nd, 1907, it was noted that adults were still mating in numbers, and larvae were also abundant; this observation made in a single field. On the 6th of the same month in the same field adults and large larvae were numerous, but eggs were relatively scarce; several egg-masses were found, however. On September 25th, a long search in this field failed to find either eggs or larvae, and but very few adults and these were extremely restless. I find unfortunately that these fragments are all that were recorded, and they leave much to be desired.

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A MONOGRAPHIC CATALOGUE OF THE MYMARID GENUS ALAPTUS HALIDAY, WITH DESCRIPTIONS OF THREE NEW NORTH AMERICAN FORMS AND OF ALAPTUS ICERYAE RILEY FROM TYPE MATERIAL.

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INTRODUCTION.

This paper is a catalogue monographic in nature, purely from the fact that as the species of the genus are listed, the original descriptions are quoted; it is not a monograph, as the types of most of the species have been inaccessible. Neither is the history of the genus touched upon to any extent on account of the lack of literature. Simply as a matter of convenience, the original descriptions of the species are given with the descriptions of the three new species here included, so that the descriptions of all the species of the genus are brought together. A preliminary bibliography of the species is also given, but it may be stated that the literature of the group is most fragmentary.

The forms in this genus are so minute and delicate, and their preservation so difficult, that it is not surprising that the types have in the main been lost, or no attempt made to keep them. The similarity of the various species in structure and color makes this most unfortunate, especially as most of the original descriptions are very inadequate. I have found that antennal structures afford the best specific characters, and these have in the main, received no attention from former systematic workers in this group. Some of the descriptions mean nothing at all, and on this account, it is a question whether the species described can be again recognized.

HOST RELATIONS OF THE GENUS.

Although the Mymaridae are supposed to be mainly egg-parasites, or we think of them mostly in that connection, yet this genus appears to be principally parasitic on various Coccidae; of the eleven species now described, the host relations of but four are definitely known, namely, the three new forms herein described and iceryae Riley; three of these were reared from some stage of various Coccidae (iceryae from the male pupa of Icerya); the other, caecilii, from psocid eggs. Hence even with these four species, there remains some doubt as to the stage of the host, excepting in the case of caecilii, and Icerya as the host of iceryae. In these last two cases the record is definite.

The host relations of the European species are unknown excepting in the case of excisus Westwood which is stated to have been reared: "from white blotches on oak leaves, evidently caused by the action of the minute larva of one of the leaf-mining Tineae (Lithocolletes?). The blotches were about 1¼ in. in diameter. The leaves were gathered on the 9th of September, 1871; and the little Mymars appeared on the 6th of October; one of the moths appeared on the 16th of September, 1871, and two other kinds of parasitic flies on the 4th of October following." (Westwood, 1879). The Australian species, immaturus Perkins, was reared "from cane leaves containing leaf-hopper eggs", but Perkins continues, "I do not feel sure that it is parasitic on these." (Perkins, 1905).

So far as the evidence goes, then, species of this genus have been reared from the eggs of Jassidae and Psocidae—immaturus Perkins (doubtfully) and caecilii Girault, respectively, the male pupae of Icerya (iceryae Riley), an aleyrodid (caecilii Girault, doubtfully), and unknown stages of the following—a tineid (excisus Westwood), and various Coccidae (globosicornis Girault, eriococci Girault, iceryae Riley). It is indicated, however, that the species are not restricted to one host only, and in order to show this more clearly, as well as to show the host relations, the following table is inserted.

It is seen from the table that the hosts of five of the species are entirely unknown (fusculus, fuscus, minimus, pallidicornis and pallipes); that in the case of two of the species (immaturus, excisus) the host is doubtful, and that with the exception of caecilii from eggs of Caecilius aurantiacus Hagen and iceryae

from the pupa of Icerya purchasi Maskell, the stage of the host is not definitely known for the four remaining species (caecilii, eriococci, globosicornis and iceryae.) Of the two undisputedly correct records, one of the hosts is a coccid pupa, and the other a psocid egg.

TABLE I. Tabular view of the recorded host relations of the species of Alaptus.

Parasite-Alaptus:	Host.	Stage of Host.	Remarks.
1. caecilii Girault	Caecilius aurantiacus Hagen	egg	
	Psocid	egg	undetermined
	Aleyrodes fernaldi Morrill	?	doubtful
2. eriococci Girault	Eriococcus araucariae Maskell	?	
	Chrysomphalus aurantii Maskell	?	
3. excisus Westwood	A tineid	?	a
4. fusculus Walker	?	?	
5. fuscus Foerster	?	?	
6. globosicornis Girault	Lepidosaphes beckii (Newman)	?	
7. iceryae Riley	Icerya purchasi Maskell	Male pupa.	
	Aspidiotus rapax Comstock	?	
8. immaturus Perkins	Jassidae	egg	doubtful
9. minimus Walker	?		
10. pallidicornis Foerster	?		
11. pallipes Ashmead	?		

a. This is doubtful, from the nature of the host, unless the egg was infested. Cf Riley and Howard, 1893.

DISTRIBUTION OF THE GENUS.

The species of the genus Alaptus occur in widely separated localities and the genus is represented in three continents: Europe (including England), North America and Australia. The species known to occur in Europe are excisus Westwood (England?; Austria—Dalla Torre, 1898), fusculus Walker (England), fuscus Foerster (Switzerland), minimus Walker (England), and pallidicornis Foerster (Germany); the North American species are pallipes Ashmead (Florida), iceryae Riley (California), globosicornis Girault (Florida), caecilii Girault (Florida, California), and eriococci Girault (California); the Australian species is immaturus Perkins (Queensland). The genus is therefore represented

between the parallels of about 52° north latitude and that of about 25° south latitude. The North American species are confined to the Lower Austral faunal region.

HISTORY OF THE GENUS.

The genus Alaptus was designated by a MS. note of A. H. Haliday's, published in Westwood's (1840) Synopsis of the Genera of British Insects, p. 79, and Walker's species, minimus, was named as type. The original description of the genus is as follows: "Tarsi pentamerous; antennae ♂ 10-jointed, filiform, 8-jointed ♀, last joint enlarged." The genus has subsequently been wrongly referred to Walker (1846) who gives a brief synoptic description of it. At this time, I do not believe that any further characteristics of the genus can be given, excepting the following, which may or may not be characteristic of this genus alone: Ocelli three in number, in a triangle on the vertex; antennae inserted below the middle of the face, unlike in the sexes; fore wings with very few discal cilia; the posterior margin near base, lobed, excised or dilated; hind wings maculate with dusky, usually smaller than the fore wings and more regular in shape; vertexal carina present: head about equal in width (dorsal aspect, natural position) to the greatest width of the thorax, the latter subequal to or slightly shorter than the abdomen; hypopygium plowshare-shaped, extending slightly beyond the abdomen; ovipositor not exserted; mandibles acute, scythe-shaped, minute (eriococci).

Family Mymaridae.
Subfamily Gonatocerinae.
Tribe Gonatocerini.
Genus Alaptus Haliday (Westwood, 1840.)
(Type—Alaptus minimus Walker.)

DESCRIPTION OF THE SPECIES.

1. **Alaptus minimus** Walker.

Westwood, 1840, p. 79.
Walker, 1846, p. 51.
Dalla Torre, 1898, p. 428.

"1. *minimus*. Ferruginosus antennis et pedibus pallidus."

It is impossible to recognize the species from this description, so that from specimens received from Washington, D. C., as hereinafter stated, I have drawn up the following description. The species was designated as the type of the genus in 1840, but was not described until six years later.

DESCRIPTION OF ALAPTUS MINIMUS WALKER.

Similar in general to the others.

Female: Scape long, slender, and curved, longer than pedicel and funicle 1 combined. Pedicel conical, stout, the margins convexly curved, wider than the scape, and thrice wider and nearly as long as the first funicle joint, its cephalic margin truncate, apparently serrate, widest at the base of the apical third and tapering proximad; the first three funicle joints slender cylindrical, the first and third subequal, but the third a little stouter than the first and second and a little longer than the first; the second one-fourth to one-third longer, the longest funicle joint , long and narrow; funicle 4 cylindrical oval, distinctly wider than 3 and shorter, subequal to 1, but a little shorter; funicle 5, subconical, the shortest and stoutest funicle joint, widest at the apex, the margins straight, a little over one-half the length of funicle joint 2, and shorter than the pedicel; club, the largest antennal joint, ovate, not exceeding the length of the 3 apical funicle joints combined, but twice wider than funicle joint 5. Setae as in the other species. (Fig. 1.)

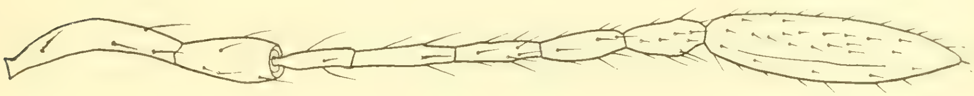

FIG. 1. Antenna of Alaptus minimus Walker, greatly enlarged. Female.

Fore wings with two rows of discal cilia along the whole of the costal margin, one of the rows sometimes obscured. Hind wings with a single long row of the same, nearer the caudal margin. (From 2 specimens. 2-3 inch obj. Bausch & Lomb.)

Male—Same as female.

Antennae filiform; scape shorter, not exceeding the length of the pedicel and funicle 1; pedicel the same; funicle joints not so slender, cylindrical; 1 the shortest, subequal to 7; 2 and 3 subequal, 2 longer, however; 1, 2 and 3 equal in width; 4, 5, 6 and 7 gradually thickening, cylindrical oval, one-fourth to one-third wider than the three proximal joints; 4, 5 and 6 subequal in length, 4 longer, however, subequal to 2; 2 and 4 the longest funicle joints; 7 one-fourth shorter than 6; the club ovate, one-third shorter than 7, and sub-equal in length to the pedicel; as thick as funicle 7. (From 2 specimens. 2-3 inch objective, Bausch & Lomb.)

Redescribed from 2 males and 2 females, beautifully mounted in balsam by Mr. Frederick Enock of London, and comprising specimens determined by an English authority and in the collection of Dr. L. O. Howard, by whom they were loaned to the author.

The antennae of the male of minimus are very distinct from those of the male of iceryae but somewhat similar to those of caecilii, from which they differ in the fact that the funicle joint 1 is not much shorter than funicle 7 and that 2 and 4 are distinctly the longest funicle joints; from those of the male eriococci they are very distinct, the funicle joints in the latter being much shorter, the first three not long and slender, but all round oval, conic, or ovate, and the apical joint is the longest funicle joint; in eriococci and iceryae males, the shape of the antennal joints are entirely different from those of minimus and caecilii.

The female antennae differ from those of female iceryae in being cylindrical at the proximal funicle joints, and entirely different structurally; from those of female caecilii, not very much, but in the latter funicle 3 is distinctly thickened, subovate, and the relative lengths of the joints are different; the club is also as long as the three distal funicle joints, or longer; besides, the colors of the insects are different; from female eriococci, in the fact that like iceryae, the joints are differently shaped.

2. **Alaptus fusculus** Walker.

Walker, 1846, p. 51.
Westwood, 1879, p. 79.
Dalla Torre, 1898, p. 428.
Ashmead, 1904, pp. 362, 365.

"2. *fusculus.* Praecedente major colore obscurior antennis longioribus? Vix revera species distincta.

These two seem to be only varieties of one species which is common on windows near London."

This description also is entirely inadequate, and as Walker observes, the species may be synonymic with minimus. I have no knowledge of the existence of valid specimens of it, and unless these exist, see no reason why the species should stand. Ashmead (1904) gives this species as the type of the genus and refers it to Haliday.

3. **Alaptus pallidicornis** Foerster.

Foerster, 1856, p. 120.
Westwood, 1879, p. 79.
Dalla Torre, 1898, p. 428.

"Das Genus Alaptus ——————; ——————; ——————. Von dieser Gattung habe ich eine neue Art, Alaptus pallidornis m. in hiesiger Gegend gefangen, sie ist kaum halb so lang wie Alaptus minimus und hat fast weisslichgelbe Fühler."

This description also is inadequate. I have retained the spelling of the specific name suggested by Westwood in 1879, and which was adopted by Dalla Torre in 1898, without explanation. This changing of specific names is useless and now without sanction unless the original is an obvious error, which I consider this to be.

4. **Alaptus fuscus** Foerster.

Foerster, 1861, p. XLIII.
Dalla Torre, 1885, p. 80.
Idem, 1898, p. 428.

"Alaptus Walk. 123. *fuscus* n. sp. ♀. Lg. 2-5 mm. Schwarz, Schaft auf der Unterseite, Spitze der Schenkel, Basis und Spitze der Schienen sowie die Tarsen gelb; Endglied der Fühler sehr gross und dick, so lang wie die halbe Geissel." Habitat: Helvetia.

This description also is inadequate for recognition of the species.

5. Alaptus excisus Westwood.

Westwood, 1879, p. 586.
Riley and Howard, 1893, p. 267.
Dalla Torre, 1898, p. 428.

"I am indebted to Mr. Whitmarch, of Wilton, near Salisbury, for an opportunity of examining a very large number of glass slides, prepared for the microscope, containing minute insects mounted in Canada balsam—an excellent plan for the examination of such objects, so far as the observation of the general outline and of detached parts are concerned, the gummy solution rendering the parts more or less transparent. Amongst these specimens I found two insects belonging to the Mymarides, which I have no hesitation in regarding as the male and female of the same species. Both specimens had been reared from white blotches on oak leaves, evidently caused by the action of the minute larva of one of the leaf-mining Tineae (Lithocolletes?). The blotches were about 1¼ in. in diameter. The leaves were gathered on the 9th of September, 1871; and the little Mymars appeared on the 6th of October; one of the moths appeared on the 16th of September, 1871, and two other kinds of parasitic flies on the 4th of October following.

The action of the Canada balsam has destroyed the colors of the insects; so that the following description is confined to structural characters; moreover the male insect has unfortunately been fixed by the Canada balsam on its side, and the exceedingly minute size of the creatures rendered any attempt at displaying them, by arranging the limbs in the usual manner, ineffectual.

The head in the male is of large size and of an oval form (seen laterally), transverse in the female and widest behind; in this sex it appears to be furnished with two large appendages, truncate at the tips, which may possibly be dilated palpi. The antennae of the male are long and filiform, 10-jointed, the basal joint being the largest, the remaining nine being nearly equal in size. The antennae of the female are 8-jointed, the first joint large, the second smaller, the third considerably shorter and thinner than the preceding, the fourth to the seventh gradually but slightly thickened, and the eighth forming an elongated oval mass. The details of the thoracic segments are not easily determined, owing to the mode of preservation of the specimens; but the scutellum seems to be of large size and semicircular. The abdomen is sessile, depressed, and gradually pointed to the tip in the female, whilst it is more ovate in the other sex, with the male organ protruded. The wings are of equal size and shape in both sexes, the posterior ones being as large as the anterior, which latter have a remarkable dilatation near the base of the posterior margin*, terminating in an acute notch; the remainder of the margins of all the wings is fringed with long hairs; the legs are long, slender, and terminated by 5-jointed tarsi with large pulvilli.

The 5-jointed tarsi, the number of joints in the antennae of the two sexes, the sessile abdomen, and the very long narrow wings, agree with the characters of Haliday's genus Alaptus given by Walker in the "Annals of Natural History", Vol. XVIII (1846) p. 50. Of this genus two or, more probably, only one species is recorded in this country, namely *A. minimus*, "ferruginosus, antennis et pedibus pallidis"; the supposed second species, *A. fusculus*, "Praecedente major colore obscurior antennis longioribus, vix revera species distincta". (op. cit. p. 51). Another species, A. pallidornis (?pallidicornis), is slightly described by Foerster, found near Aix la Chapelle. It is scarcely half as long as A. minimus, with yellowish-white antennae (Hym. Stud. II, p. 120). As these authors do not mention the singular dilated and excised base of the forewings,† I consider the one before us distinct, to which may be applied the name of *Alaptus excisus*.

A. antennis maris corpore paullo longioribus, feminae corpori aequalibus; alis anticis basi postice dilatatis et subito excisis. Insecta minutissima. Long. circ. 1-6 mill.

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* This dilatation is present at least in the females of iceryae Riley, and both sexes of caecilii Girault and eriococci Girault, and those of minimus Walker, so that the character is generic and not specific; to a less extent, it occurs in other genera. It is particularly strong in minimus.

† Compare the previous footnote in regard to this.

This species is founded on a generic character; it may or may not be synonymic with minimus Walker. The description is generic rather than specific and is inadequate for recognition of the species. The description of the antennae of the female, however, does not agree with minimus.

6. **Alaptus pallipes** Ashmead.

Ashmead, 1887, p. 193.
"112(1). Alaptus pallipes, n. sp.

Female. Length .02 inch. Black. Head very large, much broader than the rather slender thorax. Antennae 8-jointed, brown; scape short, dilated, pedical small, first funicle joint shorter than second, second longer, third short but thicker than second, fourth much longer and thicker than third, fifth still longer but not so thick, club greatly swollen, as long as the scape. Abdomen sessile, ovate, not as long as the thorax. Legs pale. Wings hyaline, with very long ciliae, the forewings spatulate, the hindwings linear.

Hab.—Florida." Type: One female in collection U. S. National Museum, Washington, D. C.

This is the first species of the genus to be described from North America. It is not listed by Dalla Torre (1898).

7. **Alaptus iceryae** Riley.

Riley, 1888, p. 130.
Idem, 1889, p. 86, Pl. XI, fig. 3.

This species has never been described. It was listed as "Alaptus iceryae n. sp." by Riley (1888) in Insect Life, in a list of parasites of the Fluted Scale in California, and again mentioned as such in the Report of the Commissioner of Agriculture for 1888 (Riley, 1889), where the female was figured, together with the details of the male antenna.

In a collection of slide-mounted Mymaridae loaned to me by Dr. L. O. Howard, I found four slides (3 ♂, 1 ♀) labelled "iceryae" most probably the original reared material from which Riley named the species. In addition to this , four more slides (bearing 3 ♂'s, 1 ♀) were found which bore the label, "Bred from male pupa of Icerya purchasi", and two slides (1 ♂, 1 ♀) marked "N. G. Mymarinae," bearing the same record and date, were found to be identical with the others. From this material I have thought it wise to draw up a description and to designate types.

Female:—Length 0.654 mm.; wing expanse, excluding cilia, 1.56 mm.; length of fore wing 0.691 mm., width of fore wing 0.45 mm. Minute in size.

Similar to eriococci Girault, but lighter in color, and slightly larger. The fore wings apparently with but a single discal seta situated about at the middle of the apical third of the wing.

Antennal structures dissimilar from those of eriococci, most noticeable in the relative lengths of funicle joints 1 and 2; in eriococci the first funicle joint is distinctly longer than wide and one-third shorter than the cylindrical joint following; in iceryae the first funicle joint is very slightly longer than wide and nearly as long as the cylindrical oval second joint of the funicle; the second

funicle joint in eriococci is distinctly twice longer than wide; in iceryae it is not more than one-third longer than wide, and sub-oval in shape, not cylindrical; in iceryae, funicle joints 1 and 2 are subequal; also in eriococci, funicle joint 2 is at least subequal to, or longer than, the third funicle joint, whereas in iceryae, funicle joint 2 is distinctly shorter than funicle 3.

Scape and pedicel normal, nearly as in eriococci; pedicel shorter and somewhat stouter, equal to, or slightly longer than the combined length of the first two funicle joints; funicle joints 1 and 2 abruptly smaller, subequal, funicle joint 1 subquadrate, joint 2 cylindrical oval; the latter about one-fourth longer. Funicle joints gradually enlarging to the club; funicle 3, elliptical oval, about one-third longer than the preceding joint, and wider; joints 4 and 5 of the funicle subequal in length to joint 3, each wider than the other, joint 4 regularly oval and joint 5 roundish ovate; funicle joints 3, 4, and 5 widest at the apical third, and none are as long as the pedicel or as wide; club regularly ovate, more regular than in eriococci. Setae the same, the basal row on the 3 apical funicle joints, however, apparently absent (high power), the apical row more distinct than in eriococci. (From 3 specimens, 2-3 inch objective, Bausch & Lomb.)

Male:—Length 0.691 mm.; wing expanse, excluding cilia, 1.45 mm.; length of fore wing 0.58 mm.; width of fore wing 0.45 mm.;

The same. Resembles very closely the male of eriococci, but is lighter in color, and slightly larger. However, at once distinguished by antennal characters. The second joint of the funicle smallest, very slightly more than half the length of the first funicle joint. This character is not present in the males of eriococci, and the less similar caecilii and minimus.

Scape and pedicel the same, the latter subequal in length to the two following funicle joints combined; funicle joint 1 suboval, distinctly longer than funicle 2, and shorter than funicle 3; funicle 2 subquadrate, about a third of the length of the next joint; funicle 3 thicker, ovate, nearly as long as the combined length of the two preceding joints, but about one-third shorter than the next joint, subequal in length to the pedicel; funicle joints 3–7 gradually widening to club; funicles 4–7 subequal in length, longitudinally carinate, the three apical joints with two distinct rows of setae at basal and apical third respectively, the basal row less distinct on funicle 4; funicles 4–7 slightly more thick at their apical third or fourth, all about one-third longer than the club joint, and thicker. The club or distal joint normal, conical, the base however rounded, and subequal in length to the pedicel, or slightly longer, less distinctly carinated. The club bears from 3 to 4 rows of sparse long setae, the three proximal funicle joints one each distad (in the middle of the basal funicle joint); and funicles 3–7 acute at their apico-lateral angles (high power). (From 7 specimens, 2-3 inch objective, Bausch & Lomb.)

Described from 7 males, and 3 females, mounted in balsam and received for study from Dr. L. O. Howard. These specimens were labelled as follows: "Bred from male pupa of Icerya purchasi. (Coquillett.)", 6 males, 3 females, bearing dates of May 24, July 19 and 23, August 4, 17, 22 and 25, and October 4, 1887; and "Bred from Aspidiotus convexus, November 28, 1887", 1 male. The species was therefore reared by Mr. D. W. Coquillett in California from the male pupae of Icerya purchasi Maskell and from some stage of the Greedy Scale, Aspidiotus rapax Comstock. The second species of the genus to be described from North America, Alaptus pallipes Ashmead being the first.

Types:—No. 11938, U. S. National Museum, Washington, D. C., 3 ♂, 1 ♀ (the 4 slides originally labelled iceryae.) Cotype, Accession No. 37489, Illinois State Laboratory of Natural History, Urbana, Illinois, 1 male, 1 female (2 slides).

This species was also overlooked by Dalla Torre (1898).

8. **Alaptus immaturus** Perkins.

Perkins. 1905. p. 197.

"Alaptus, Hal.

Antennae of female 8-jointed, the scale elongate, the second joint dilated and much wider than the following, third slender, elongate, rather shorter than the fourth, 5th, 6th, and 7th, increasing in width, club nearly as long as the four preceding. Antennae of male 10-jointed, the scape elongate, second wider than the following, third elongate, but shorter than the fourth, which is subequal to the following joints. Posterior ocelli close to the eye-margins, the three forming a triangle with extremely wide base. Tarsi 5-jointed. Abdomen sessile. (Plate XII, fig. 5; antennae of female in two aspects, and that of the male.)

Alaptus immaturus, sp. nov.

Female: Pallid ochreous, the head sordid and also the thorax along its posterior margin; abdominal segments with obscure, sub-quadrate, lateral, blackish or sordid spots. Antennae with two basal joints pale, the rest dark. Length 3-8 mm.

Hab.: Bundaberg, Queensland, bred from cane leaves containing leaf-hopper eggs, but I do not feel sure that it is parasitic on these."

The descriptive portion under the generic heading refers to the species, but the arrangement is unfortunate; the description lacks many details which could just as well have been given.

9. **Alaptus globosicornis** species nova.

Female: Length, 0.1999 mm; wing expanse, excluding cilia, 0.58 mm.; width of fore wings, 0.0273 mm.; length of fore wings, 0.23 mm. Very minute.

General color uniformly pale brown; the legs, excluding the intermediate and posterior tarsi, paler; eyes and ocelli red; margins of the fore wings yellowish brown. Body impunctate, smooth. Fore wings normal, discal cilia entirely absent excepting two distinct solitary ones in a line in the middle of the base of the distal third of the wings; marginal cilia abruptly increasing in length on the posterior margin at the distal fifth of the wing; the distal cilia largest, at least 2 1-2 times as long as the greatest width of the fore wing; fore wings spatulate, gradually widening just beyond the basal third which is linear, and widest at distal fifth, the apex narrowly rounded; one margin slightly concaved at distal fifth; distal cilia transparent a short distance beyond their insertion, forming a distinct white path a slight distance from the margin of the wing and following the outline of the distal part of the wing. Hind wings mottled with dusky, without discal cilia, clavate, a short row of cilia near the margin in the wing surface (high power). Body, including antennae and legs, bearing scattered setae. The vertexal carina present, apparently as in caecilii. Thorax and abdomen about equal in length.

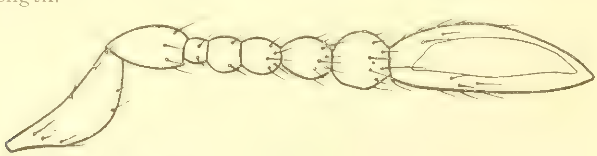

Fig. 2. Antenna of Alaptus globosicornis, greatly enlarged. Female.

From 2 specimens. 2-3 inch objective. Bausch & Lomb.

Male:—Unknown.

Barely visible to the naked eye when held to the light.

Legs normal, the anterior tibial spurs long, slender and curved; apparently two, but if not, then one forked beyond the basal half.

Antennae pale brown, concolorous with body, the funicle, however, very slightly dusky. Scape, pedicel, and club bearing sparse, scattered, setae; the funicle joints delicately subverticellate, each with two more or less regular

whorls of uneven setae on the apical half (high power). Scape convexly curved, about as long as the next four joints combined; pedicel subconic, as broad as the scape, narrower than club, and as long as the next two joints combined; funicle moniliform, each joint globular, funicle 1 abruptly smaller than the pedicle, and slightly smaller than funicle 2; funicle joints 2 and 3 subequal, funicle 3 slightly larger, both somewhat larger than funicle 1; funicle joints 4 and 5 each increasing somewhat in size; funicle joint 5 at least twice larger than funicle joints 2 and 3, and 1-3 larger than funicle 4; club undivided, abruptly larger than the funicle and cylindrical oval in shape; it is from 1-3 to 1-2 wider than either the scape or pedicel, and as long as the 4 apical funicle joints combined; club bearing a few scattered setae, a little more numerous at base. (Fig. 2.)

Described from two females mounted in balsam, received for determination from Dr. L. O. Howard, Chief of the Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C., and labelled as follows: "Morrill No. 2008, Bred from Purple scale, VIII, 10. 1907. E. A. Back." Therefore reared from Lepidosaphes beckii (Newman), the Purple scale, Orlando, Florida. Stage of host not indicated.

Type: No. 11858, U. S. National Museum, Washington, D. C., 2 females.

The characteristic of this species is the moniliform funicle of the antennae, quite unlike in structure that of any other species of the genus now known.

10. **Alaptus caecilii** species nova.

Female:—Length 0.327 mm.; wing expanse, excluding cilia, 0.909 mm.; width of fore wings, 0.0546 mm.; length of fore wings, 0.399 mm. Minute.

General color uniformly bright lemon yellow. Eyes and ocelli red, legs uniformly pale yellowish, venation and margins of the fore wings dusky yellow; head slightly darker. Body normal, bearing scattered setae, apparently smooth. Vertexal carina present, running across the cephalic margin of the vertex between the eyes, and on each side back (caudad) around the inner margin of the eye, over the apex of the eye, touching the lateral ocellus, around to the (outer) caudo-lateral aspect of the eye; the part following the margin of the eye is alternately dark and pallid as though consisting of small varicolored segments, while the transverse part is solid or with larger alternate segment-like colorations, or pale laterad. After rounding the apex the carina is not so close to the apical (caudal) eye margin. Eyes subcordate in shape, moderately coarse, naked. Ocelli in a triangle on the caudal part of the vertex; apparently red and yellow, or particolored, the lateral ocelli touching the occipital margin, and the distance between them and the eyes is twice greater than that between either and the margin of the eye. Median line of thorax pale, grooved; parapsidal furrows apparently absent, at least inconspicuous. Ovipositor slightly exserted.

Wings normal, as in globosicornis but larger, the fore wings margined with dusky yellowish, the discal cilia entirely absent with the exception of a single short middle row consisting of from 3 to 6 cilia. Hind wings mottled with dusky, as in globosicornis; the row of cilia near the margin of the wing surface, guarding the marginal cilia, longer and stronger (high power). Legs normal; anterior tibial spurs long, slender and curved; the others minute; as in globosicornis.

Antennae concolorous with body. Scape short, one margin nearly straight, the other regularly convex, about one-third longer than the pedicel, and as thick in the middle; pedicel ovate, the distal end truncate, however; thicker by 2 times and somewhat longer than the first funicle joint; funicle joint 1 cylindrical slender, one-third shorter than the pedicel and funicle 2; the latter equal in width

to the preceding joint, but one-third longer, subequal in length to the pedicel, and nearly a third larger than funicle 3; funicle joint 3 shorter, equal in length to funicle, 1, or somewhat longer, and cylindrical oval, therefore somewhat thicker than the preceding funicle joints; funicle gradually thickening from the third joint to club; funicle joints 4 and 5 subequal in length and width, oval, thicker than the joint immediately preceding but somewhat shorter, nearly equal in length to funicle joint 1; funicle joint 4 very slightly longer than joint 5 of the funicle, the latter not as large as in the figure. Club undivided, abruptly longer and broader, with 2 paler furrows visible from one side; it is as long as the three preceding joints combined, and about twice the length of the scape, and ovate in shape, the base rounded, the apex tapering; club uniformly hairy. Antennae bearing rather sparse soft hairs beyond the second joint of the funicle, most numerous on the club, but sparser on funicle joints 1 and 2; scattered on the pedicel and scape; in general a single whorl on funicle joints 1 and 2, and 2 on joints 3–5 of the funicle, and more or less uniform on the club. (Fig. 3). (From 39 specimens. 2-3 inch objective Bausch & Lomb.

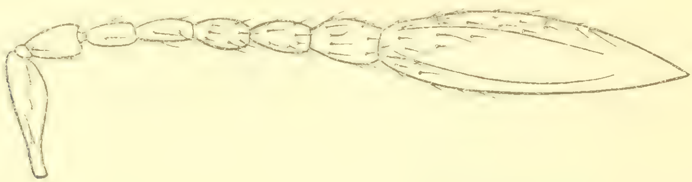

Fig. 3. Antenna of Alaptus caecilii, greatly enlarged. Female.

Male:—Length, 0.326 mm.; wing expanse, 0.873 mm.; width of fore wings, 0.455 mm.; length of fore wings 0.382 mm.

The same. Antennae 10-jointed, filiform; scape and pedicel the same, the first funicle joint, however, a little more than half the length of the pedicel, and the second funicle joint, or nearly two-thirds the length of the latter; funicle joint 3 a little longer than the second joint, funicle 4 about 1-4 longer, and thicker than funicle 3; funicles 4, 5, 6, and 7 subequal in length and shape, and truncate, slightly wider anteriorly and bearing a thicker seta from each apical corner; preceding joints cylindrical; club or apical joint conical, shorter than the preceding funicle joint. Antennae thickening uniformly beyond the third funicle joint; flagellum, excluding the scape, apparently longitudinally striate; clothing as in female, the hairs slightly more sparse in the male. (From 2 specimens. 2-3 inch objective, Bausch & Lomb.

Described from two males and thirty-nine females mounted in balsam. The species is larger than globosicornis, lighter in color, and the antennae entirely different structurally. Otherwise they are superficially alike. I have before me the following specimens kindly transmitted by Dr. L. O. Howard: Six slides marked: "Morrill No. 2009. Bred from Psocid eggs, Orlando, Fla., VIII, 5, 1907. E. A. Back" (3 slides, 14 females); "Morrill No. 2002. Hymenopterous parasites of eggs of psocids (1005) on orange leaves. 1 specimen bred; 1 specimen taken on leaf near eggs. A. W. Morrill, 2.13–1907. (See Morrill No. 2009)", (1 slide, 2 females); and "Morrill No. 505. Hymenopterous parasite from breeding box containing Spiræa leaves infested by Aleyrodes fernaldi Morl., from Amherst, Massachusetts. 9–20–1906", (2

slides, 2 females). Five slides from the collection U. S. Department of Agriculture marked—"Alaptus sp. From eggs of Caecilius aurantiacus Hagen. Los Angeles, Cal., July 30, Aug. 15, 29, 1888. Coquillett." (5 slides, 1 male, 11 females). Four slides from the same collection marked as follows: "From eggs of Psocus, July 13, 15, 17, 21, 1888. Coquillett." (4 slides, 1 male, 10 females). The males were reared June 30 and July 21, 1888.

This species is therefore parasitic on the eggs of Caecilius aurantiacus Hagen at least, and is found in both California and Florida; I am inclined to think the record from Aleyrodes fernaldi Morl. as due to accidental presence of the parasites, and perhaps their host, in the breeding box containing the Aleyrodid, though it is quite within the range of possibility that they are parasitic on it. I think this not the more probable, however, especially in view of the fact that the host was from the north.

This species is undoubtedly the one referred to by Howard (1894). Habitat: Florida; California; ? Massachusetts.

TYPE: No. 11859, U. S. National Museum, Washington, D. C., many balsam specimens, ♂ ♀; Cotypes, Accession No. 37491, Illinois State Laboratory of Natural History, Urbana, Illinois, 2 ♂, 5 ♀, in balsam; and Cotype No. $\frac{1905}{26151}$, Milwaukee Public Museum, 3 females, balsam specimens.

11. **Alaptus eriococci** species nova.

Female:—Length 0.618 mm,; wing expanse, excluding cilia, 1.44 mm.; width of fore wing 0.394 mm.; length of fore wings, 0.618 mm. Minute in size. General color uniformly dark brown, distinctly darker but very similar to iceryae Riley. Eyes dark red, ocelli red and yellow, in a curved line in the middle of the vertex. The lateral ocelli not touching the occipital margin; antennae, legs and margins of the wings concolorous, or slightly paler. Vertexal carina present, similar to that in caecilii. Body impunctate, with a few scattered setae.

Wings normal, nearly regularly spatulate, little or no curve at the apical fifth; a single short row of 3–4 discal cilia beginning at the apical half of the wing. Hind wings spatulate, marked as in the preceding species.

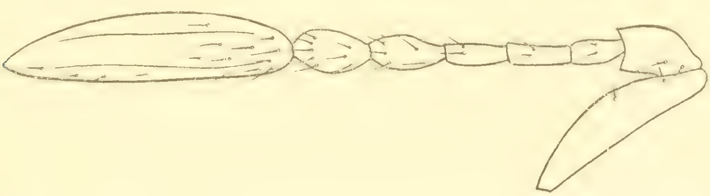

FIG. 4. Antenna of Alaptus eriococci, greatly enlarged. Female.

Antennae somewhat similar to those of iceryae, but they increase in size less regularly; distinct from those of globosicornis and caecilii. Scape more uniform, not increasing much in width at the middle but rather slender and regularly convex, nearly as long as the next four joints combined; pedicel at

most one-third the length of the scape, longer than wide, subcuneate in shape, wider than the scape and much more so than the following joint, about two-thirds the width of the club, and slightly shorter than the combined length of the first two funicle joints; funicle joint 1 the smallest joint, longer than wide, one-third shorter than funicle joint 2; the latter cylindrical, twice longer than wide, subequal to or slightly longer than funicle joint 3 which is inclined to be a little thicker and shorter; joints 4 and 5 of the funicle suboval, joint 4 one-third wider than funicle 3, and one-third narrower than funicle 5, and about subequal in length to funicle joints 2 and 3; the apical joint of the funicle more round, and slightly shorter; club normal, not as long as the combined length of the four preceding joints, but longer than that of the three preceding joints; subequal in length to the scape but twice wider, or nearly so. Setae on antennae as in caecilii. (Fig. 4). (From 11 specimens, 2-3 inch objective, Bausch & Lomb.)

Male:—Length, 0.620 mm.; wing expanse, excluding cilia, 1.44 mm.; width of fore wings, 0.394 mm.; length of fore wings, 0.618 mm.

The same, more slender. Antennae 10-jointed, filiform, longitudinally striate, more finely so in the pedicel; dissimilar from those of caecilii and iceryae, the shape of the segments more similar to the latter species; in eriococci the first funicle joint is the shortest, about half the length of the pedicel, but in iceryae the second funicle joint is distinctly the smallest, about, or slightly less, than half of the pedicel, while in caecilii the first funicle joint is the smallest and more than half the length of the pedicel.

Scape and pedicel as in the female; first funicle joint globose, not two-thirds the length of the following joint (funicle 2) which is cylindrical, longer than wide and subcuneate in shape; funicle joints 2 and 3 subequal; joints 4, 5, 6, and 7 subequal, wider and one-fourth longer than the joints 2 and 3, more hairy and slightly more rounded; apical or club joint pointed ovate, rounded at base and tapering somewhat to tip from the middle, narrower than joints 4–7 of funicle but subequal in length; joints 2–7 truncate apically, and widening very slightly from the 4th joint, the apical angles acute. Setae as in the female; single rows on joints 1 and 2 of funicle, on joint 3 a second row represented sometimes, and on joints 4–7 two distinct rows in the middle respectively of the proximal and apical halves of the segments. (Fig. 5.) (From 25 specimens. 2-3 inch objective, Bausch & Lomb.)

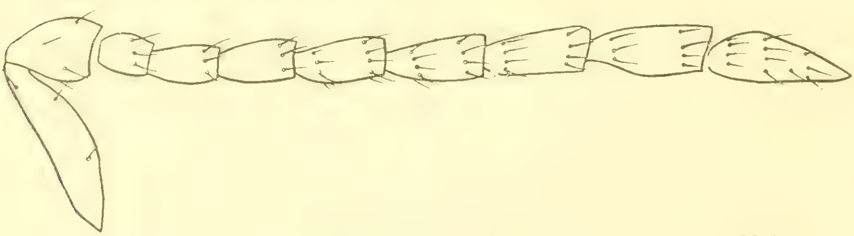

Fig. 5. Antenna of Alaptus eriococci, greatly enlarged. Male.

Described from 25 males and 11 females mounted in balsam, received for study from Dr. L. O. Howard, Chief of the National Bureau of Entomology, and forming a part of their Collection of Mymaridae. The specimens were labelled as follows: "Bred from Rhizococcus araucariae. August 29, 30, 1887 (5 ♂, 4 ♀), and September 1–5, 1887, (19 ♂, 7 ♀)", and "Bred from Aspidiotus aurantii (San Gabriel Valley), Los Angeles, California, Sept. 9, 1887 (1 ♂)." Therefore reared from Eriococcus araucariae Maskell and the Red Scale of California, Chrysomphalus aurantii (Maskell). Habitat: Los Angeles, California.

TYPES: Type No. 11937, U. S. National Museum, Washington, D. C., 16 males, 5 females, (3 slides). Cotypes: Accession No. 37490, Illinois State Laboratory of Natural History, Urbana, Illinois, 3 males, 3 females.

This species is very similar to Alaptus iceryae Riley females, but the males are distinct. The females of the two species may, however, be distinguished by the dissimilar antennal structures.

TABLE OF SPECIES.

This table includes those species only which have been accessible to me or have been described sufficiently well to enable diagnostic characters to be selected.

FEMALES.

A. Species yellow.
 Club joint as long as the 3 apical funicle joints combined, the latter oval, the 2 proximal funicle joints cylindrical, funicle 1, one-third shorter than funicle 2; fore wings with 4–5 discal cilia. **caecilii**

B. Species brown, or yellowish brown.
 1. Proximal funicle joints cylindrical, slender, longer than the apicals. Club joint not as long as the 3 apical funicle joints combined; the 2 apical funicle joints oval, the 3 proximal ones cylindrical, slender; funicle 2 the longest joint of the funicle, funicle 5 shortest, subequal to 1; fore wings with 2 long rows of discal cilia near the costal edge, one of which is often obscured; no cilia in the disk or center of wing............**minimus**
 2. Proximal funicle joints short, subquadrate, rectangular, ovate or conic; not cylindrical and slender, or much longer than the 2 apical joints; club equal in length to the 3 apical funicle joints, or longer.
  a. Dark brown; proximal funicle joints rectangular, the 2 apical funicle joints unequal, funicle 5 globose, much larger than funicle 1—the shortest funicle joint; funicle 2 twice the length of funicle 1 and the longest of the 3 proximal funicle joints; fore wings with 2 discal cilia.............................. **eriococci**
  b. Light brown; proximal funicle joints quadrate, the 2 apical joints subequal, funicle 2 but one-third longer than funicle 1, and intermediate in size of the three proximal funicle joints; fore wings with a single discal cilium.. **iceryae**
 3. Joints of funicle globose, the funicle moniliform, funicle joints 2 and 3 subequal, club equal in length to the 4 apical funicle joints; wings with but 2 discal setae............**globosicornis**

C. Species black.
 Proximal funicle joints unequal, the second longer, the 4th and 5th joints much longer than the third joint.................**pallipes**

MALES.

A. Species yellow.
 Antennal joints subequal in length, the club and funicle 1 shortest; fore wings with 4–5 discal cilia..........................**caecilii**

B. Species brown, or yellowish brown.
 1. Proximal segments of funicle cylindrical, slender, much longer than wide. Antennal joints subequal in length, slender, the club and funicle 1 shortest, excepting perhaps the pedicel, funicle joints 2 and 4 longest of the flagellum; fore wings with 2 rows of discal cilia along the costal margin.................**minimus**

2. Proximal segments of antennae short, ovate or quadrate, not much longer than wide.
   a. Dark brown; flagellar joints uniform, gradually increasing in size, funicle 1 shortest, globose; funicle joints 2 and 3 subequal; fore wings with 2 discal cilia. **eriococci**
   b. Light brown; flagellar joints uniform, gradually increasing in size, funicle 2 shortest, about one-third the length of 3; funicles 1 and 3 unequal; fore wings with a single discal cilium........................**iceryae**

LITERATURE REFERRED TO.

1840. Westwood, John Obadiah. Synopsis of the genera of British insects. Introduction Modern Classification of Insects; etc., London, II, p. 79.

1846. Walker, Francis. Annals and Magazine of Natural History, London, XVIII, p. 51.

1856. Foerster, Arnold. Hymenopterolgische Studien, Aachen, II, p. 120.

1861. Foerster, Arnold. Progr. Realsch, Aachen, p. XLIII.

1879. Westwood, John Obadiah. Trans. Linnaean Soc. London, Zoology, I, p. 586, table 73, figs. 10, 11.

1885. Dalla Torre, Carl G. de. Jahresbericht Naturf. Ges. Graubunden. XXVIII, p. 80.

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1887. Ashmead, William Harris. Canadian Entomologist, London, Ontario, XIX, p. 193.

1887. Cresson, Ezra Townsend. Synopsis Hymenoptera of America, North of Mexico. Trans. American Ent. Soc., Phila., Supplementary volume, 1887, pp. 85, 137, 250.

Alaptus Walker, 1846. On page 250, in the catalogue of the described Hymenoptera of American North of Mexico, under Alaptus is given Elaptus aleurodis Forbes, 1884, the only species listed. Elaptus aleurodis Forbes is not a mymarid, and is synonymic with Amitus aleurodinis Haldemann. Cf. Forbes (1885).

1888. Riley, Charles Valentine. Insect Life, United States Department of Agriculture, Division of Entomology, Washington, D. C., I, p. 130.

1889. Idem. Report of the Entomologist, in Report of the Commissioner of Agriculture, 1888. United States Department of Agriculture, Washington, D. C., p. 89, pl. XI. fig. 3.

1893. Riley, Charles Valentine and Leland Ossian Howard. The smallest insect known to Entomologists. Insect Life, United States Department of Agriculture, Division of Entomology, Washington. D. C., V, p. 267. (Howard, Standard Natural History, Kingsley, Boston, II, p. 512.)

Brief note in answer to correspondent. Alaptus excisus Westwood the smallest insect known to date, being but .17 mm. long. Probably parasitic on the eggs of a coccid.

1894. Howard, Leland Ossian. The Hymenopterous parasites of the California Red Scale. Insect Life, United States Department of Agriculture, Division of Entomology, Washington, D. C., VI, p. 228.

Alaptus sp., evidently caecilii Girault, reared by Coquillett in 1887 or 1888 at Los Angeles, California, from orange leaves infested with the "Yellow Scale" and therefore at first thought to be parasitic on that insect; afterwards reared in large numbers from the eggs of Caecilius aurantiacus Hagen and is therefore most probably not a coccid parasite, the true host eggs being overlooked in the first rearings.

1904. Ashmead, William Harris. Classification of the Chalcid flies of the superfamily Chalcidoidea, etc. Memoirs Carnegie Museum, Pittsburgh, pp. 362, 365.

Alaptus Haliday; type given as fusculus Haliday.

1905. Perkins, R. C. L. Bull. No. 1, Part 6, Division of Entomology, Hawaiian Sugar Planters' Association, Honolulu, p. 197. (Report of Work of the Experiment Station of the Hawaiian Sugar Planters' Association.)

ACKNOWLEDGMENTS.

It gives me pleasure to acknowledge the kind assistance of Dr. Henry Skinner, of the Academy of Natural Sciences, Philadelphia, Pa.; that of Mr. C. R. Crosby, of Cornell University, Department of Entomology; and that of Mr. Charles T. Brues, Curator of Invertebrate Zoology, Milwaukee Public Museum. I wish to thank these gentlemen especially for furnishing abstracts of the literature.

I am particularly indebted to Dr. L. O. Howard, Chief of the Bureau of Entomology, U. S. Department of Agriculture, for the specimens upon which the descriptions in this paper are based, and for the opportunity of studying a large series of European Mymaridae, besides many other kindnesses.

For the figure of the antenna of Alaptus minimus Walker, I am indebted to Mr. J. D. Hood, of the University of Illinois; and for redrawings of the others from camera lucida tracings, to Mr. William D. Matthews, formerly of this office.

THE INTERNAL ORGANS OF REPRODUCTION OF THE MALE SAW-FLY, CIMBEX AMERICANA LEACH.

Henry H. P. Severin and Harry C. M. Severin.

(with plate xii.)

HISTORICAL.

The male organs of reproduction of various Hymenoptera have been the object of study of a number of naturalists. Swammerdam (35), Réaumur (25), Dufour (10), Leydig (21), Leuckart* and more recently Cheshire (6), Koschewnikoff (20), Bordas (3), and Michaelis (22) have all worked on the reproductive organs of the drone bee. Schneider (31), in his general considerations upon the development of the reproductive organs of insects, has devoted some time to the Cynipidae and Ichneumonidae. Kluge (19) has worked on the male genital organs of Vespa germanica. Bordas (3) carried his research to several genera belonging to various families of Hymenoptera often not closely related. A number of other naturalists:—André (1), Schmiedeknecht (30), Hoffer (17), Radoszkowski (26, 27, 28), Verhoeff (37) and Zander (38, 39) have carried on their study on the external genital apparatus of various Hymenoptera.

A few authors have extended their investigations to different species of the family Tenthredinidae. Burmeister (32) figures and describes the external genital armature of Cimbex variabilis.

Dufour (10) described the anatomical relation of the reproductive organs of a number of species belonging to this family; viz., Cephus pygmaeus, Tenthredo cincta, Tethredo rustica, and Hylotoma enoides. In Cimbex he describes the large accessory glands or glandulae mucosae as vesiculae seminales. In all the figures of the various species of Tenthredinidae he has made this same mistake.

After Dufour, Leuckart has treated in a general way the male reproductive organs of Anthidium and Athalia. Bordas (3) quotes nearly in-extenso his work which we reproduce as follows:—"La structure des testicules consiste, chez les Anthidium, en une série de trois conduits séminifères qui se continuent par un canal déférent commun. Chez l'Athalia, ils sont constitués par une

* Paper not accessible

suite de poches arrondies. Les canaux déférents sont longs, grêles et s'entrelacent parfois pour former des testicules secondaires (Athalia). Les glandes accessoires, en forme de conduits terminés en cul-de-sac, s'insèrent à des hauteurs variables, le long des canaux déférents."

Raymond (29) in his work upon the organization of Nematus ribesii Scopoli has described, in a general way, the reproductive organs of this species. He writes, "Les vésicules séminales de ces insectes sont piriformes, au nombre de deux, et elles mesurent environ 1 millimètre de longueur; le canal déférent qui les surmonte est un tube court, s'anastomosant avec son voisin, après un faible parcours, pour former le canal éjaculateur qui s'ouvre entre les armatures sexuelles.

Près de leur partie postérieure et latéralement, chacune des vésicules porte un tube à parois transparentes et épaisses, ayant $0^{mm}07$ de diamètre. Ces tubes, que nous n'avons pu suivre jusqu'à leur extrémité, représentent les testicles et ont une certaine analogie avec les ovaires des femelles. Les vesicules ont des parois très épaises, vaguement fibreuses; elles sont très contractiles et contiennent un liquide laiteux chargé de globules arrondis et très petits. Malgré tous nos efforts, nous n'avons pu constater aucun mouvement propre à ces corpuscles."

A dissection of this species revealed to us that he has made the same mistake as Dufour, in calling the accessory glands or glandulae mucosae the seminal vesicles.

Packard (24) in his text book of entomology copied Newport's (23) figure of the male reproductive organs of the saw-fly, Athalia centifoliae but modified the description as follows:—

Newport's description.	*Packard's description.*
(a) The smaller testes.	a, a, testes.
(b) The duct.	b, b, epididymis.
(c) The large pair of testes. (d) The efferential vessel.	c, d, vas deferentia.
(e) The vesiculae seminales.	e, vesiculae seminales.
(f) The approximation of their ducts.	f, ductus ejaculatorius.
(g) Extremity of the penis.	
(h) Ejaculatory duct.	h, penis.

A comparative study of our work on Cimbex americana shows that the male reproductive organs are very similar to those of the saw-fly, Athalia centifoliae figured by Newport and copied by Packard. It appears to us that Packard in his revised explanation of Newport's figure has fallen in to the same error as Dufour,

calling the large accessory glands or glandulae mucosae, the vesiculae seminales. The vasa deferentia of Packard's explanation correspond to the vesiculae seminales of Cimbex and the epididymes to the vasa deferentia. Newport's description of the male reporductive organ of Athalia centifoliae is so far from correct that it is hardly worth consideration.

ANATOMICAL DESCRIPTION.

The male organs of reproduction of Cimbex americana consist of six principal parts:—the testes, the seminal ducts (vasa deferentia), the seminal vesicles, the accessory glands (glandulae mucosae), the ejaculatory ducts and the external genital armature.

The testes are paired (Fig. 1, t) and are situated on each side of the alimentary canal, in the sixth abdominal segment. They are kidney-shaped and are completely embedded in adipose tissue. When this adipose tissue is carefully dissected away, it is found that the testes are enveloped by a thin membrane ("capsule enveloppante" of Bordas (3)).

A number of tracheae originating from the fifth and sixth abdominal spiracles (Fig. 2, 5s and 6s) send off numerous branches which penetrate this membrane and hold the testes in their lateral position. One main trunk, which originates near the fifth abdominal stigma, gives off a number of branches to the anterior and of the testis (Fig. 2, tr); those tracheae which originate from the sixth abdominal spiracle send off, near the inner margin of the testis, numerous branches which divide and redivide, forming a network on the generative organ.

Each testis sends off from its inner median margin a very thin cylindrical tube, the vas deferens (Fig. 1, vd). Both vasa deferentia pass backward as straight tubes through the seventh abdominal segment and widen rather abruptly in the anterior region of the eighth segment to form the seminal vesicles. The seminal vesicles make several convolutions (Fig. 1, sv) and then communicate posteriorly with the large accessory glands (Fig. 1, o).

The aceessory glands or glandulae mucosae are a pair of hooked glands with the distal ends enlarged and rounded, while the posterior portion of each gradually narrows into a duct (Fig. 1, gm). The two glandulae mucosae diverge and are obliquely inclined on each side of the anterior region of the rectum. These glands partly conceal the last abdominal ganglion, which sends nerves to them.

From an external view one cannot say with certainty just where the ducts of the glandulae mucosae end and the ejaculatory ducts begin. The latter are two short cylindrical tubes which continue side by side and only join at their terminal extremity to open to the oustide. Zander (39) describes the ductus ejaculatorius of Cimbex variabilis as a "enges Rohr, das den Penis durchzieht."

HISTOLOGICAL DESCRIPTION.

Testis: A study of sections cut through the testis shows that the club-shaped testicular follicles are surrounded by a thin membrane ("capsule enveloppante" of Bordas) which contains small ovoid nuclei. Numerous tracheae penetrate this membrane and branch and rebranch in the space between the testicular follicles. A delicate network of loose fibrous connective tissue is present in the space between the testicular follicles.

The testicular follicles open into an enlarged portion of the distal end of the vas deferens, the so-called collecting reservoir, which is excentrically placed within the testis. Each testicular follicle does not always open separately into this collecting reservoir, but oftentimes two or more join with one another before opening into it.

A longitudinal section parallel to the surface of the testis shows that the epithelial layer of the collecting reservoir extends for a short distance into each testicular follicle. The epithelium consists of a layer of flattened cells, with cell boundaries indiscernible; each cell contains an ovoid nucleus. The epithelial cells rest upon a basement membrane. External to this membrane is a branching muscle layer, which continues for some distance on each testicular follicle. In our work upon the female reproductive organs of Cimbex (34) we found branching anastomosing muslces in the egg-tubes extending to the apex of the ovariole, being present in even the terminal filament.

Vas deferens: The vas deferens is made up of the following layers passing from without, inward:—1, a very much folded, peritoneal membrane; 2, a longitudinal branching muscle layer; 3, a muscle layer composed of transversely striated circular and oblique fibres; 4, a basement membrane and 5, an epithelial layer consisting of elongated cells with cell boundaries not discernible.

Seminal vesicle: With the exception of that region of the seminal vesicle, which is near the opening into the glandula muco-

sa, the histological structure is similar throughout its entire extent. The external peritoneal membrane covers a thin layer of longitudinal branching muscles. Within these are the circular muscles which often run obliquely. Next within, is a layer of epithelial cells with cell boundaries indiscernible, each cell containing an ovoid nucleus embedded in a granular protoplasm. The long axis of the nucleus is usually parallel with the free ends of the epithelial layer (Fig. 6, nep.) Within the lumen are bundles of spermatozoa which are embedded in a secretion.

Near the opening of the seminal vesicle into the glandula mucosa the structure of the former differs from that just described. The circular muscles are better developed, being from two to three layers in thickness. The cells gradually increase in size, cell boundaries are usually apparent and the nuclei assume a position at right angles to the free ends of the cells (Fig. 3, nc). These cells gradually pass over into the large cells of the glandula mucosa (Fig. 3, c.)

The openings of the seminal vesicles into the glandulae mucosae are directed posteriorly towards the ducts of these glands. On this account the sperms in passing from the seminal vesicles into the mucous glands probably never reach the distal end of the latter, but pass directly into the ducts of the glands and then into the ejaculatory ducts. In all our sections we did not find any sperms in the large swollen ends of the glandulae mucosae, a fact which supports the above view.

Accessory glands: A transverse section through the accessory glands shows that the epithelium is thrown into a number of large folds which almost fill the lumen (Fig. 3). The epithelial layer of the swollen distal part of the glands consists of exceedingly long cells with cell boundaries usually well defined (Fig. 4). Each cell contains a single ovoid nucleus with its long axis parallel to the same axis of the cell. The position of the nucleus varies within the cell; occasionally it is found near the free end, sometimes near the middle, but more often the nucleus is found near the basal region of the cell. These cells are glandular and contain numerous droplets of secretion (Fig. 4, g). The epithelium rests upon a thin basement membrane, outside of which are the muscle layers. Within the folds of the epithelial layer are branching muscles which are not so well developed as the external circular muscles. External to the circular muscles is a very thin delicate peritoneal membrane.

The glandular nature of the epithelial cells is shown by the presence of secretory processes which are somewhat similar to those that we have described and figured in the mid-intestine of Cimbex (33). Bordas (4) in his investigation upon the male reproductive organs of Coleoptera has described secretory processes in the accessory glands of a species of Lucanus and Dorcus parallelipipedus. In the process of secretion of Cimbex the free end of the cell becomes swollen causing it to project above the glandular cells at rest (Fig. 4, gl). The swollen mass elongates and assumes a more or less pyriform shape (Fig. 5, A). Further stages can be found in which the globules are still in direct continuity with the protoplasm of the cell, from which they originated, by a fine pedicel. Finally the globule becomes free by strangulation and floats in the lumen of the glandula mucosa (Fig. 5, B).

Since Zander (39) who has worked on the morphology of the male genital apparatus of various Hymenoptera, has described the ejaculatory ducts and penis of Cimbex variabilis, we made no further attempt to examine these parts in Cimbex americana.

We are deeply indebted to Prof. Wm. S. Marshall for the use of literature which was borrowed from his excellent entomological library.

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EXPLANATION OF PLATE XII.

All figures were drawn with a camera lucida.

Fig. 1. Dorsal view of reproductive organs: *t*, testis; *vd*, vas deferens; *sv*, seminal vesicle; *o*, entrance of seminal vesicle into glandula mucosa; *gm*, glandula mucosa; *cd*, ejaculatory duct. (X 16).

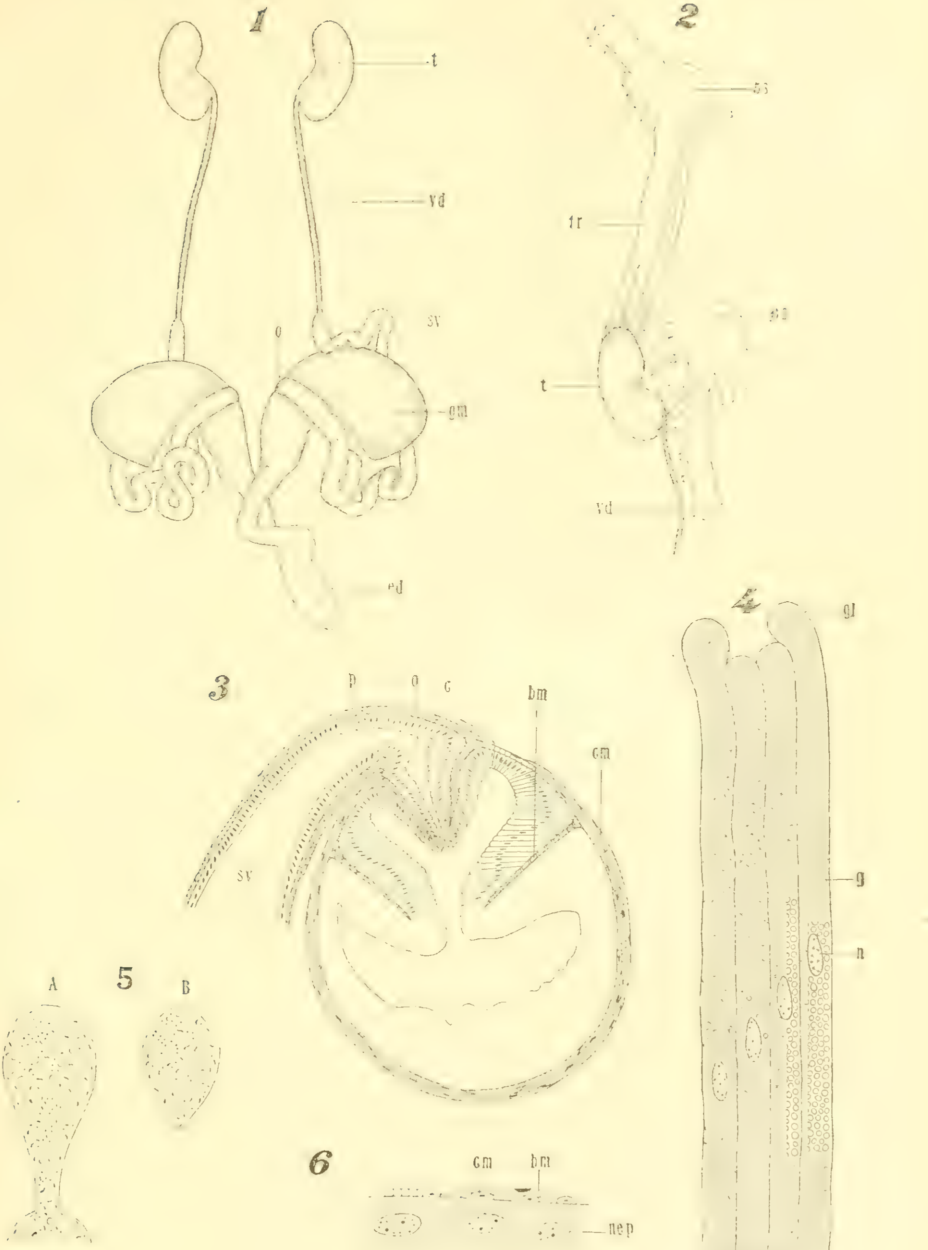
Fig. 2. Tracheae which hold the testis in its lateral position in the abdomen: *5s*, fifth abdominal stigma; *6s*, sixth abdominal spiracle; *tr*, trachea, which gives off a number of branches to the anterior end of the testis; *t*, testis; *vd*, vas deferens. (X17).

Fig. 3. Section through seminal vesicle and glandula mucosa, showing the opening of the former into the latter: *nc*, nuclei changing their direction; *sv*, seminal vesicle; *p*, peritoneal membrane; *o*, opening of the seminal vesicle into the glandula mucosa; *c*, cellular change; *bm*, branching muscles within the folds; *cm*, circular muscles. (X60).

Fig. 4. Exceedingly long cells of glandula mucosa: *gl*, swollen end of cell in the early process of forming a secretory globule; *g*, droplet of secretion; *n*, nucleus. (X650).

Fig. 5. Secretory processes: A, pyriform secretory process in direct continuity with the protoplasm of the cell from which it has originated; B, globule which has become free by strangulation. (X1300).

Fig. 6. Longitudinal section throughout the middle of the seminal vesicle: *cm*, circular muscles; *bm*, branching muscles; *nep*, nucleus. (X650).



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A PRELIMINARY STUDY OF THE ARANEAE THERAPHOSAE OF CALIFORNIA.

CHAS. PIPER SMITH.

CONTENTS.

Comparatively little work has been done upon the trapdoor spiders and tarantulas of North America. Popularly, the trapdoor species, Bothriocyrtum californicum (Cteniza) and the tarantulas, Eurypelma (Mygale hentzi, etc.), are well-known from the numerous specimens put up and sold by natural history dealers; but our various other forms are practically unknown to most zoologists and entomologists, and have received very little attention.

N. M. Hentz, the pioneer of American arachnology, writing between the years 1821 and 1850, described six species of Araneae theraphosae, all from the South-eastern States. Two of these are male and female of one species, however, and are the same as one of the five species attributed to North America by H. Lucas, a Frenchman, whose papers appeared from 1834 to 1845. Walckenaer, also a Frenchman, in a work published in 1837, named four North American forms, only one of which goes by his name today. In 1852, Girard published Mygale hentzi. Rev. O. P.

Cambridge, of England, published Cteniza californica in 1874, and nine years later, Atypoides riversi. Anton Ausserer, of Vienna, has published (1871–1875) four species of Eurypelma, one the same as E. hentzi Girard, and two from the manuscript of Doleschall. Prof. Geo. Atkinson, of Cornell University, was the next American to add to the literature upon these forms, describing seven species in 1886, all from Virginia and North Carolina. At least two of these had been already described. Geo. Marx (1888) and Nathan Banks (1896), both of Washington, D. C., have each described one species. Eugene Simon, of Paris, who has made a more comprehensive study of the spider fauna of the world than any other student, has described eighteen North American species. Cambridge and Atkinson have added to their descriptions accounts of the ecology of the forms they describe; but many of the species have not had their habits and haunts investigated and recorded, indeed many of them, apparently, have not been collected, or recorded since the original descriptions appeared.

Four listings of the North American species of the Araneae theraphosae have been made. Geo. Marx (1889), in his "Catalogue of the Described Araneae of Temperate North America," lists 29 species. Simon, in his "Liste des Especes de la Famille des Aviculariides qui habitent l'Amerique du Nord" (1891), enumerates 37 species, 18 of which are his own, and 13 of which are therein described for the first time. Nathan Banks (1892), in his paper entitled, "Our Atypidae and Theraphosidae", recognizes but 23 species, he evidently not having considered Simon's paper of the preceding year. Lastly, J. H. Comstock (1903) in his publication, "A Classification of North American Spiders," lists 36 species; or 37 if Simon's reference to an Avicularia from San Diego be considered.

Of these 37 forms, 18 are attributed to the Pacific Coast, 17 to California. All have been described by men situated in the Eastern United States or in Europe, from material sent to them. It is no wonder, therefore, that our species have been described mostly from meagre and young material, and the ecology of so few has been recorded.

The following list sums up the species reported from California, embodying the redistribution of certain forms, as found necessary from the study of my material:

Aviculariidae
  Ctenizinae
    Hebestatis theveneti Simon (Cycloscosmia)
    Bothriocyrtum californicum, Cambr. (Cteniza)
    Eutychides versicolor, Simon (Actinoxia)
    Aptostichus atomarius Simon
    Aptostichus clathratus Simon
    Aptostichus stanfordianus sp. nov.
    Amblyocarenum talpa Simon (Cyrtauchenius)
  Aviculariinae
    Avicularia sp. (?)
    Eurypelma californica Auss.
    Eurypelma leiogaster Auss.
    Eurypelma steindachneri Auss.
    Eurypelma rileyi Marx.
    Eurypelma marxi Simon
  Diplurniae
    Brachythele longitarsis Simon
    Brachythele theveneti Simon
Atypidae
    Atypoides riversi Cambr.
    Aliatypus californicus, Banks (Atypoides)
    Hexura picea Simon.

Marx and Banks have followed the older classification of Ausserer. Comstock has, however, followed the newer classification of Simon, as given in his "Histoire Naturelle des Araignees," Vol. I (1892, as to part dealing with the Araneae theraphosae). I likewise, follow Simon, in general; but in the supplement of this work, published in 1903, Simon makes certain changes in classification, which concern certain of our North American forms, affecting Comstock's tables, and attracting special attention to one of the species found about Stanford University.

The family Atypidae, formerly, was divided into three sub-families, the Brachybothriinae, Hexurinae, and Atypinae, each comprising two genera. All three sub-families are represented in North America. All the rest of our Araneae theraphosae were placed in the family Aviculariidae. By Simon's new arrangement, the family Atypidae is limited to the two genera of the old "Atypinae," the other two sub-families being transferred to the Aviculariidae; the change, however, not at all affecting the

sequence established earlier. The old family Atypidae was characterized by the elevated position of the anal tubercule, the normal number of the spinnerets being six (the genus Brachybothrium excepted), and the lower border of the chelicerae being narrow and without a distinct groove for the reception of the fang. The family as now limited, is distinguished by the great development of the coxal lobe of the pedipalps, the four pairs of sternal impressions, and the presence of a conductor on each genital bulb of the male. The Brachybothriinae have no coxal lobes on the pedipalps, no suggestion of a conductor on the genital bulbs; but have a rake on the chelicerae, the thoracic furrow is longitudinal, and the sternal impressions are four in Brachybothrium, six in Atypoides. The Hexurinae have only two sternal impressions and no rake, the thoracic pit is longitudinal, there is a suggestion of a coxal lobe on the pedipalps and the genital bulbs have a short spur, probably analogous to the conductor of the Atypinae.

The species which becomes of special interest in connection with these groups of Simon's, is Banks' Atypoides californica. The male of this species seems to be unknown to science, so I take pleasure in reporting the finding of two males, October, 1907, in the immediate vicinity of Stanford University. A casual comparison of these specimens with the drawings of the male of Atypoides riversi Cambr., shows marked differences between the two species, and a careful study of the facts at hand, shows the necessity of the formation of a new genus to accomodate the species described by Banks. The female of this species is quite close in structure to the female of Atypoides riversi, having a rake and six sternal impressions; but the thoracic pit is round, not longitudinal. The male has a rake, the thoracic pit round, short coxal lobes on the pedipalps, much as in Hexura, and also has a conductor on each genital bulb, nearly the full length of the bulb. How it differs otherwise from Atypoides will be discussed in the proper place below. In truth, the female of Aliatypus, as the new genus will be called, seems to merit a position nearer the Brachybothriinae, while the male, in certain respects, belongs rather between the Hexurinae and the Atypinae. Such a condition of affairs makes a readjustment of Simon's classification of these forms worthy of consideration. The affinities of Aliatypus toward Atypus, however, are thru "secondary sexual characters" in the male, which, if of as little weight in classification as some

authors argue, are not so important as the characters, common to both sexes, placing the genus between Atypoides and Hexura.

Altho I have not studied specimens of Brachybothrium, Hexura and Atypus, and have not seen the genus Scotinoecus, which Simon considers as linking Brachybothrium to the Diplurinae, it seems to me that Simon's Atypidae of 1892 is more worthy of recognition as a family than his limited Atypidae of 1903. Accepting, accordingly, the older Atypidae as a family, the group logically admits separation into five natural smaller groups, whether of sub-family or tribal rank is not important. Arranged in the form of a key, these groups may be characterized as follows:

Spinnerets 4, sternal impressions 4, chelicerae with a rake, no coxal lobe, thoracic pit longitudinal........................ Brachybothrium (1)
Spinnerets 6:
  Chelicerae with a rake, sternal impressions 6, coxal lobe none or slightly produced in male.
    Coxal lobe none, thoracic pit longitudinal, bulb of male without conductor .... Atypoides (2)
    Coxal lobe apparent in male, thoracic pit round, bulb with long slender conductor................................ Aliatypus (3)
  Chelicerae without a rake.
    Coxal lobe small, sternal impressions 2, thoracic pit longitudinal, bulb with a stout spur...............................Hexura (4)
    Mecicobothrium
    Coxal lobe very large, sternal impressions 8, thoracic pit transverse, bulb with long conductor........................Atypus (5)
    Calommata

One other difficulty that comes up in following Simon's late classification is in regard to his groups Cyrtauchenieae and Amblyocarenieae, of the sub-family Ctenizinae. These groups are separated from each other upon the basis of the relative size of the posterior sternal impressions and the relations of these two impressions to each other and to the margin of the sternum. As to these characters, I find that in two of the species of the Ctenizinae found in this vicinity, that the young answer the requirements of one group while the adults claim admission to the other group. In truth, the sternal impressions seem to be characters that vary according to the age or size of the individual, at least in some species, and should be used with caution in classification. This point will be taken up further, in the discussion of the species concerned.

From the number of forms of the Araneae theraphosae described from California, and with Simon's latest work and Comstock's recent "Classification of North American Spiders" at hand, it was supposed that the species found about Stanford

University could be readily identified, leaving only the life habits of the forms needing investigation. It was soon found, however, that the species collected were far from being easily determined, and developments soon showed that a problem in systematic work was really at hand. Thus it was deemed advisable to press first the solution of the taxonomic questions, even if the biological phases of the problem had to be neglected. Efforts were therefore made to secure good series of all the species obtainable, and in some cases very satisfactory results were obtained.

The territory covered is not extensive, not nearly as much so as desirable, but many days have been spent in careful field work in the immediate vicinity of Stanford University. The mountains west of Stanford have been visited to the extent of the Woodside-Kings Mt. Road, and the ravine west of, and below, King's House, the base of the Woodside–La Honda Road, the Goat-Ranch Canon and the New Grade Road, the Page-Mill Road, and the Los Gatos Canon, from Wrights down. In the Mt. Hamilton Range, the lower portion of the Alum Rock Canon was visited, and material was secured at various points along the Mt. Hamilton Stage-road from San Jose. A special trip was made to Santa Rosa, Sonoma County, as this was then supposed to be the type locality of Simon's Aptostichus clathratus. Material was secured at the base of the hills due east of Petaluma, at White Sulphur Springs, south-east of Santa Rosa, and along the Guerneville-Forestville Road, near the Russian River. Finally, the gulches in the pine forest of the Monterey Peninsula, and the Monterey-Sur County-road, yielded valuable returns for the time spent in that vicinity.

The only way of locating the nests of the spiders is by careful search for the traps or open burrows, in likely places, as learned by experience. Frequently, after a considerable rain, the burrow is deepened and pellets of soil, held together by silken thread, are carried out and piled up near the burrow, such piles being often much more noticeable than the trapdoors, and even more so than the uncovered openings. In moss-covered banks, a very popular resort, the trapdoors are commonly almost beyond discovery by human ken, but frequently a practiced eye may detect a flattened space in a mass of moss which may be lifted up and seen to be a trapdoor. Sometimes the free edge of the door will be quite noticeable to one accustomed to detecting them. In general, they are quite indiscernible to the casual observer,

altho in a conspicuous place. The chimneys, or "turrets," of Atypoides are more or less conspicuous and attract common attention. "Tarantula holes" are well known to almost every-one, where tarantulas occur.

A nest once located, the soil is carefully dug away with a small miner's pick, the details of the measurements, directions, branches (if any), and silk lining being studied and recorded in a field-book, each specimen being given a permanent number and page in the book. The more careful exposing of the burrow is done with a pair of small forceps, with curved points, the pick being used for the rougher digging only. The spider is stored away in a cork-stoppered bottle, a slip of paper bearing the number assigned the individual always being fastened in between the cork and glass. The composition of the trapdoor or turret and its surroundings are usually recorded, and any other notes considered to be of possible interest or use.

In the laboratory, the spiders are put into about 75% alcohol and laid aside for later study, each in a separate vial and under the number given it in the field. Spiders corked up as brought in from the field have been found to be thoroly alive after having been thus confined for a full week, without fresh air. They die very slowly in potassium-cyanide killing bottles. For study they are placed in a watch-crystal and kept under alcohol, or they are laid out on a blotting-paper or white cloth and allowed to dry for half an hour or so, when most of the external structures are studied with a hand-lens, a dissecting, or a compound, microscope; but if left out over an hour, without moistening with a couple of drops of alcohol, the abdomen is apt to shrink, thus deteriorating the specimen. For especially careful study of such portions as the rake of the chelicerae, tarsal claws, etc., dissections carefully mounted in balsam give the most satisfactory results. Even then it is noticed that with such uneven topography as many spiders possess, "things look different" from different angles and much care is necessary to make a series of comparative drawings worth anything.

The following key is given to aid in identifying the species discussed in the remaining pages.

(I) With four spinnerets.
- (1) Chelicerae with a rake
  - (a) Tarsi I and II not scopulate .... **Bothriocyrtum**
  - (aa) Tarsi I and II densely scopulate
    - (b) Coxa P with spinules scattered from base to apex (Plate XIV, fig. 16) .... **Eutychides**
    - (bb) Coxa P with spinules limited to inner basal corner (Plate XIV, fig. 17) .... **Aptostichus**
      - (c) Cephlx. distinctly appressed–pubescent, eye-tuber very high (Plate XIV, fig. 31) .... **A. atomarius**
      - (cc) Cephlx. apparently glabrous, eye-tuber much lower Plate XIV, figs. 22 and 23) .... **A. stanfordianus**
- (2) Chelicerae without a rake
  - (a) Tarsi of legs lacking third claw; abdomen long-setose and short-velvety .... **Eurypelma**
  - (aa) Tarsi of legs with third claw; abdomen short-silky pubescent, not setose .... **Brachythele**

(II) With six spinnerets
- (1) Thoracic pit longitudinal; ♂ without conductor on genital bulb, pedipalps half as long as legs I .... **Atypoides**
- (2) Thoracic pit round; ♂ with conductor on genital bulb and pedipalps as long as legs I .... **Aliatypus**

Bothriocyrtum californicum, Cambr. (Cteniza). In Mogg., Harvesting Ants and Trapdoor Spiders, II (Supp.), 1874.

This is the well-known trapdoor spider of Southern California, whose thick, bevel-edged trapdoor and nest is commonly sold by natural history dealers. The species was probably more or less common in the Santa Clara Valley, before the days of plowing and cultivation. I have been unable to find any trace of it since my searchings began. Dr. Jenkins reports the finding of a nest on his Cedro Cottage premises, sometime about 1890. The specimen is supposed to be deposited with the Entomological Museum of the University, but unfortunately there seems to be no specimen here labeled as such. It may be one of two unlabeled specimens that are here. The only other report that I have come across is in Science, III, 62, Notes and News, p. 476 (1884), which, however, states that a new Cteniza has been found at San Jose, different from the one found in Southern California, and may, indeed, refer to something else. As it gives no reference, the report is probably worthless. Bothriocyrtum, however, probably persists yet in some isolated, uncultivated areas in this county, and may be expected to come to light at any time in the future.

Eutychides versicolor, Simon. (Actinoxia). Act. Soc. Linn. Bord., XLIV, p. 318.

(Plate XIII, figs. 1–19; XIV, figs. 1–16; XVI, figs. 1–2).

Simon's Actinoxia was based upon a very young individual, only 8 mm. long, and is not retainable as a genus. Simon himself

has already recognized this fact, and says: "Le genre Actinoxia sera sans doute à supprimer et à rèunir à Aptostichus, il est basè sur un très jeune individu et ses caractères tiennent peutêtre a l'âge" (Hist. Nat. des Ar. II, Supp., p. 900). I have collected, and have before me, one male and over seventy-five females, ranging in length from 7 to 26 mm., not including several broods of young taken from the nests of the parents, to be mentioned later. A careful study of several individuals, ranging in length from 7 to 12 mm., has satisfied me that I have the species treated as above by Simon. There is a specimen of this form, 14 mm., long, in the collection here, labeled, "Actinoxia versicolor Simon, det. by Banks." The adults, however, cannot be referred to Actinoxia, nor can they be placed in Aptostichus; but their more important and more constant characters conform best to Simon's diagnosis of Eutychides (Ann. Soc. ent. Fr., 1888, p. 213), (Hist. Nat. des Ar., I, p. 109), especially as to the posterior sternal impressions and the armature of the pedipalps. The species seems to be closely related to E. dugesi Simon (Ann. Soc. ent. Fr., 1888, p. 214), but is certainly distinct.

It is the most common trapdoor spider of the Santa Clara Valley, the foothills and canons on either side. It is the only form that I found while in Sonoma County. I did not find it in the portion of Monterey County visited. Mr. Banks records it from Sierra County (Proc. Cal. Acad. Sci.–Zool. III, 13, 1904, p. 332). It is probably well distributed throughout the Coast Ranges of California.

As both male and female adults are undescribed, I insert rather full descriptions, including generic as well as specific characters.

Adult ♀ (Plate XVI, fig. 1)—Length 26 mm.; cephalothorax 2 mm. long, 7 mm. wide; abdomen 12 mm. long. Cephlx. olivaceous-tawny, cephalic portion darker, margins lighter, apparently glabrous, the scattered minute black setae showing up only under a good lens, posterior margin usually decidedly emarginate; thoracic-pit procurved; a row of much larger, black, cephalad-bent setae along median line of caput, with a narrow glabrous space on each side; caput high, prominent, rapidly narrowing within the middle third, slightly narrowing thru posterior third (Plate XIII, figs. 7–8, 11–12); eye-tuber low, hardly one-fourth as high as long (i. e., longitudinal thickness) (Plate XIV, figs. 5–7); eyes of the Amblyocarenum type, anteriors nearly equidistant, P. L., nearly as large as A. L., P. M. not constant in size or shape (some individual variations shown in Plate XIV, figs. 9–12—fig. 13 showing an abnormal lack of two posterior eyes on one side), A. L. and A. M. dark blue-gray, P. L. dull yellowish, P. M. shining silvery-white. Chelicerae dark reddish, long setose at the apex with attenuating tongues of setose areas reaching to the base above (Plate XIII, figs. 11–12), with a slight obtuse process at the apex within (more noticeable if mounted in balsam) rake (Plate XIII, figs. 15–18) of many teeth, but only four in front, two of which are on the low process, a prominent row of five or more teeth extending up the

inner edge of the chelicerae, (in most young individuals the front row of four are conspicuously larger than the other teeth above and behind—figs. 17–18—and no doubt are responsible for the "Actinoxia" rake described by Simon); fang with a thin scollop-edged median extention within (figs. 16 and 18). Abdomen oval or elliptical, dull tawny, marked with purplish-brown median stripe and transverse bands, very dark, broad, and more-or-less confluent, nearly obscuring the ground-color, or pale and nearly obsolete (Plate XIII, figs. 9–10). Spinnerets as shown in last mentioned figures. Sternum pale tawny, black-setose; three pairs of shallow impressions, posterior pair large, irregularly elongate, oval, ovate, or kidney-shaped (some variations shown in figs. 1–6, Plate XIII), close together and converging cephalad, appearing paler than the surrounding cuticle, because of the absence of fine black setae; anterior pair not apparent in young individuals (fig. 6) and posterior pair smaller, farther from each other and nearer the margin, the younger the individual. Labium a little wider than long, more or less emarginate in front, generally unarmed (67%), but frequently with one to three scattered spinules (33%) (Plate XIII, figs. 13–14). Coxae of pedipalps with many spinules from base to apex of ventral surface, more concentrated cephalo-mesad (Plate XIV, fig. 16; setae not shown); tarsi of pedipalps densely scopulate below, well armed two subapical spines and two others on each margin (71%) (Plate XIII, fig. 15P); next joint armed with numerous spinose setae, but without well-defined arrangements. Legs tawny, or with a decided olivaceous cast; tarsi I and II with two sub-apical spines (86%) metatarsi I and II with four apical spines and two near each margin (78%), frequently, however, one of the apical and the inner of the sub-basal spines are reduced to little more than spinous setae, scarcely distinguishable from the numerous variable setae omitted from the drawing (Plate XIV, fig. 15 I); patella III with a triangular patch of spines, comprising a basal row of from four to six, and four to eight scattered ones above, the number commonly not uniform on the two sides of the same individual (Plate XIV, fig. 14), tibiae III with a few spines above and metatarsi III with marginal rows of spines above and below; femora IV with an apical comb dorso-cephalad, metatarsi IV with a row of spines on each side below and on the inner edge above, with at least two apical spines above and two or more below, tarsi IV with armature very indefinite, the spines varying from none to seven. Tarsal claws usually with one or two larger basal teeth and an inner graduated row of from four to eight smaller teeth, the largest nearest the apex (Plate XIV figs. 1 and 2); occasionally the number is much reduced (Plate XIV, figs. 3 and 4).

The percentages given above are deduced from tabulations made from a careful comparison of forty-three individuals.

Adult ♂ (Plate XVI, fig. 2)—Length 13 mm.; cephalothorax 5 mm. long, 4 mm. wide; abdomen 6 mm. long, 3 mm. wide. Setae everywhere much more robust and blacker than in female. Cephlx. rich tawny (the caput dappled with olive-drab, excepting the glabrous longitudinal bands on either side of the median row of setae), conspicuously bristly, especially the margins, posterior margin scarcely emarginate; thoracic pit recurved, as in female; caput much lower and relatively much smaller than in female, only half as wide as thorax, sides nearly straight, arrangement of setae as in female; eyes and eye-tuber as in female. Chelicerae much smaller and more slender than in female, darker in color; rake of fewer teeth above. Abdomen with median band not in evidence, but transverse bands nearly confluent, the pigment arranged in rings all over the dorsum, but more confluent in the bands; spinnerets conspicuously paler, light yellowish, more slender, the terminal joint relatively longer and nearer size of medial joint. Sternum as in female, outline and impressions well represented by fig. 3, Plate XIII, but the most anterior pair of impressions less apparent. Labium with setae only, no spinules; anterior edge not emarginate. Pedipalps short, less than half as long as legs I (see photo); coxae P with spinules from base to apex, but these less numerous, very slender, almost microscopic, and more confined to the anterior half; tibiae nearly twice as long as the patellae, attenuated toward the apex; bulb nearly simple, the lower surface with a nearly

complete ring running out upon the curved spine (Plate XIII, fig. 19). Legs rich tawny above, dulled by an olive tint over the areas beset with stout black setae, paler below; tarsi I and II unarmed below, scopulate, metatarsi I thinly scopulate, with basal half bent, with four apical spines and a low conical projection near the middle of the outer edge, metatarsi II scopulate, with four apical, one inner lateral, and three outer lateral spines, tibiae I and II with apical and lateral spines (no comb nor spur as in E. guadalupensis) and the numerous spinose setae common to all the joints except the tarsi; tarsi III and IV unarmed, thinly scopulate below, slender setose above, metatarsi III and IV with four apical spines, and two lateral and one median rows of slender spines, tibiae III and IV with several more scattered spines, patellae III and femora IV as in female, but the setae more robust, making the spines less conspicuous. Tarsal claws as in female, but the teeth relatively longer, more slender and conspicuous. (Described from the single individual taken.)

Altho this species belongs in Eutychides rather than in any other described genus, there are certain characters which may be considered by some as sufficient basis for a new genus; but I think it best to leave the matter as herein considered, at least until opportunity is had to examine the Mexican species of the genus.

The burrow of this species is long and narrow, with usually one of two types of a lateral branch, and a thin "wafer" trapdoor at the surface. In adobe soil, or compact sand, the branch is generally below the upper third of the burrow and is a very neat lateral chamber, about three centimeters long (with adult spiders) 10 to 12 mm. diameter within, with a circular sharp-edged opening (5 to 8 mm. diameter) into the main tube, which is enlarged at this place. In soft loamy soil in wooded canons and along streams, the branch is usually near the surface, is of less definite size and shape, and joins the main tube by a larger, less regular opening, the whole branch having the appearance of being the old abandoned upper end of the nest. Such it may be, but it evidently serves the purpose of the lateral chamber, for in no case have I found below the neater, more horizontal chamber. In only one case have I found the spider in the chamber. It is not closed by a trap door. The burrow is well lined thruout with an opaque-white sheet of silk, a whiteness which I have learned to recognize as belonging to this species, in comparison with the other trapdoor species found here. On wooded hillsides and along thicketed banks, where the species is apt to be most abundant, and where much dead grass, fallen leaves, and other vegetable debris occurs, the silken tube is frequently extended up thru the loose mass for from one to eight centimeters, supported and decorated on the outside by whatever may be near, weedstems, dead grass, loose soil, moss, leaves, etc., but always the

entrance closed by the trapdoor, except for which a few could be easily mistaken for "turrets" of Atypoides. In these above-ground extensions the rim is usually a little inflated, funnel-like, the door resting more-or-less loosely upon the rim. In such cases the door is commonly a small leaf, or leaf-portion, with just enough silk to hinge it in position and form a lace-work on the under side, in which the spider can fasten its claws. In open situations, the trap is generally level with the soil surface, in level or somewhat slanting spots, and is composed of a thick lining of silk below with a complete layer of soil above, more-or-less decorated with moss or leaf-bits, always assimilating its surroundings. One of the largest burrows examined was 27 cm. deep, 14 to 18 mm. diameter, with trapdoor 14 x 12 mm.; lateral chamber only 6 cm. down, with 7 mm. opening and 13 mm. greatest diameter. Another was 28 cm. deep, 15 to 18 mm. diameter; trapdoor 25 x 16 mm. (unusually large); lateral chamber 18 cm. down with 9 mm. opening and 3.5 cm. long. The one male found was in a typical burrow, with typical trapdoor, lateral chamber, and silk lining.

No knowledge was gained concerning their feeding habits, except that near dusk the spiders are found out at the surface, with the trap raised just a little, enough for the hidden animal to see out, evidently watching for a chance to grab some passing insect. If the door is touched, the spider may jump out at the stick, or other object, extended, and then hurriedly retreat into the depths of the nest; again it may fasten its claws in the silk lining of the trap and hold the door down firmly. If the door is forced open, it will hastily retreat to the bottom of the tube.

The eggs must be laid sometime in the summer, as females with the abdomen much enlarged and the egg-filled ovaries showing thru the ventral skin have been taken in March and June. Females with young running about in the nest were taken in September, October, and December.

Young taken from the nest of the parent and placed in individual vials, with an inch of loose moist soil, burrowed into the soil, within a few hours, with few exceptions, and placed neat little traps (measuring about 5 x 4 mm.) at the proper place. At various times certain of the doors were removed, new ones being usually built within a few hours. One which neglected putting a door to its burrow, finally did so, after being disturbed with water, two months later. In general, they were sadly neglected as to being supplied with food; but once, upon removing some of

the traps, certain ones came out at once, as if to learn the cause of the disturbance. A live mosquito, presented by forceps to one little spider, was savagely seized and carried into its tube. An injured house-fly, placed near the burrow of another young spider (5 mm. long, or less), was vainly tugged and pulled at for some time. When noticed at the surface, with the trap raised just a little and disturbed, they would commonly hold the door down as do the adults.

Not a few specimens were found to have a colony of minute mites on the anterior slope of the abdomen above; the whole colony, of thirty or more, measuring little more than a millimeter across. Minute Collembolae are commonly found running about in the nests.

Aptostichus Simon. Actes Soc. Linn. Bord., 1892, p. 317.

This genus, with its two described species, was made known by Simon in his "Liste des Especes de la Famille des Aviculariides qui habitent l'Amerique du Nord." I find no record of the genus having been collected or studied since; but Simon, in his Histoire Naturelle (II, Supp., p. 901), adds a few male characters not mentioned in the original diagnosis. The two species, as given, are:

A. atomarius .... California (Morrison)
A clathratus . . California: Sta. Rosa del California (Geo. Marx).

I have collected, and have before me, two species which I believe belong to this genus, and, indeed, seemingly differ from it only in the character of the sternal impressions, which in one species are of the type described for Eucteniza and Cyrtauchenius, in the other nearer Amblyocarenum, not at all as in Stenoterommata, as illustrated in the Histoire Naturelle (I, p. 102). As in Eutychides versicolor, the smaller the individual, the relatively smaller, less pronounced, and farther apart are the sternal impressions, both posterior and medial,—at least such is the case in the new species described below. Still, altho Simon's type specimens were presumably comparatively young individuals (14 and 15 mm. long, respectively), I find in my specimens of the same size, and smaller, no excuse for interpreting the sternal impressions as being of the Stenoterommatan type, ascribed to Aptostichus. The type of A. clathratus is in the U. S. National Museum, at Washington, and Mr. Nathan Banks has recently examined the specimen, at my request. He writes, "The sternum shows no

impressions, on each posterior side is a faint depression, but no true impressions, * * * " Mr. Banks also informs me that it is from Santa Rosa Island (near Santa Barbara), not Santa Rosa, Sonoma County. The type of A. atomarious is, unfortunately for me, in France, and the specific type locality not recorded. Until I have collected in many other portions of California, and satisfied myself that a genus exists, in this State, having the sternal impressions, and other characters, ascribed to Aptostichus, I do not feel justified in proposing a new genus to include my material now assigned to that genus.

Aptostichus atomarius Simon. loc. cit.

I have two specimens, large females 25 and 27 mm. long, respectively, taken along the Sur County-road, near Carmel, south of Monterey, December, 1907. These show some variations from the description of A. atomarius, but agree with that form too well, in what seem to me to be the more reliable specific characters, for me to try to establish a new species upon this limited material. A sufficient series, however, including many ages and sizes, may lead to other conclusions later on. I searched several hours for additional specimens, on the day these two were found, and returned several days later, going over the same and adjacent ground, but all in vain.

Plate XIII, fig. 32, shows the sternal and labial characters as represented in these two individuals, excepting that, in the one drawn, the labium has three spinules, while in the other it is unarmed. The anterior two of the six impressions are quite distinct. The eye-tuber is much higher than in the next species, is very prominent (Plate XIV, figs. 30 and 31), but is not mentioned by Simon. The abdominal markings are of the pattern shown in Plate XIII, fig. 27. The pale appressed pubescence of the cephalothorax, as well as the shape, thoracic-pit, etc., is well shown in Plate XVI, fig. 3, and needs no lens for its discovery. The armature of the pedipalps and legs show some interesting variations: Tarsi P with two sub-basal spines, one individual having also a small sub-apical spine, externally; tibiae P with three apical spines, each lacking one of the four other spines to be expected, the missing spines not corresponding as to position. Tarsi I and II unarmed, considerably shorter than metatarsi; metatarsi I with one to three small apical spines and one to three other short stout spines, not constant in position;

metatarsi II with two or three apical spines and three or four others on the basal half, varying as to position. Patella III with a more or less triangular patch of from 10 to 18 stout spines, as in the next species. Tarsi IV unarmed in one specimen, in the other, each with four spines.

The specimens were taken from their nests, which were in sandy banks along furrows cut in the hillside during heavy rains. The burrows were short, but of large diameter, measuring only 13 and 15 cm. long respectively, and varying from 18 to 25 mm. in diameter; much enlarged externally, but the silk tube itself contracting somewhat, the space thus left between the heavy silk tube and the solid soil being filled with loosely mixed sand and silk, this mass being readily pulled out with the trapdoor, etc. In one case the surrounding soil had washed away considerably, leaving the mass of silk and sand protruding some 15 mm. from the bank. Near the center of the external surface of this mass, which had a more or less laminated appearance, was the rather thick trapdoor, of sand and silk, measuring about 20 x 15 mm.

Aptostichus stanfordianus sp. nov.

(Plate XIII, figs. 20–31; XIV, figs. 17–29; XVI, figs. 4–5.)

Adult ♀ (Plate XVI, figs. 4–5)—Measurements from my largest specimen, No. 137: length 21 mm.; cephlx. 9 mm. long, 7.5 mm. wide; abdomen 11 mm. long. Cephalothorax tawny, slightly or decidedly olive-tinted, darker along furrows bounding caput; apparently glabrous, the scattered pale tawny minute hairs noticeable only under a good lens; posterior margin nearly straight or somewhat emarginate; a row of pale colored cephalad-bent setae along median line of caput; caput medium in convexity, the caudal-converging sides forming nearly straight lines (Plate XIII ,figs. 25 and 28); eye-tuber nearly black, about half as high as long (Plate XIV, figs. 22–24); eyes as in Amblyocarenium, variable (Plate XIV, figs. 19–21) A. E. blue-gray, P. L. yellowish-white, P. M. opaque-white, conspicuously luminous. Chelicerae darker than cephalothorax, with alternating glabrous and setose areas above, the setose lines fusing near the apex, apex merely rounded; rake of many teeth (Plate XIII, figs. 20–21), extending well up the inner edge above; fang smooth and rounded on inner edge. Abdomen oblong to elliptic; yellowish-brown, marked above with a median series of dark brown blotches, larger cephalad, and lateral series of cephalad-converging short linear spots, with various less definite spottings in between—the basis of these spots being rings of pigment, distinct in the lightly-marked specimens, but confluent and more-or-less obsolete, as rings, in the heavily-pigmented individuals (Plate XIII, figs. 26–27). Spinnerets four, the superior pair as shown in the last mentioned figures. Sternum tawny, decidedly olivaceous in the darker specimens, black-setose; six impressions, the anterior pair not apparent in many individuals, but readily seen in sterni dissected out and mounted in balsam, posterior pair medium in size, elongate elliptical to nearly round, almost as close to each other as to the margin (in adults) or much nearer the margin than to each other (in young individuals) (Plate XIII, figs. 29–31), darker in color than the rest of the sternum, probably because of thicker walls to the epithelial cells at these spots, as seen under the compound microscope. Labium wider than long, emarginate in front, with three to ten spinules, in a well defined transverse row or scattered (Plate XIII, figs. 22–24). Coxae

of pedipalps with many spinules cephalo-mesad below (Plate XIV, fig. 17); tarsi P densely scopulate below, with two sub-apical and two sub-basal spines (97%); next joint with four sub-apical spines (the middle two often quite slender) and two laterals on each side (83%) (Plate XIV, fig. 29 P), also setose. Legs tawny, more or less olivaceous mesad; tarsi I and II unarmed, not setose, metatarsi I not setose, but with two apical spines and two laterals near outer margin, one near inner margin (88%), metatarsi II slightly setose, with three apical spines and two laterals on each margin (79%) (variations from the formulae here adopted as typical are mostly due to the addition of one or more spines, usually slender ones not affecting the arrangement or presence of the spines of the typical system) (Plate XIV, fig. 29 "I" and "II"); patellae III with a patch of distinct spines, ten to fifteen, or more, usually with two curved rows below and the remainder scattered above, commonly not constant in number on opposite sides of an individual (Plate XIV, fig. 18); femora IV with a dense bunch of black setae at the outer apical edge, but not spinose as in Eutychides versicolor; tarsi IV commonly spined, but without constant formula, occasionally unarmed; legs otherwise as in other species of Aptostichus. Tarsal claws with two or three large inner basal teeth, more or less continuous with the basal end of the outer row of small teeth (Plate II, figs. 25–28). I can see no real difference between the anterior and posterior claws as to the teeth.

The above description is based upon a series of twenty-five individuals, ranging from 10 to 21 mm. length, the percentages given above, however, taken from tabulations made when but twenty-one were at hand. My No. 102 is taken as the type specimen, and deposited in the Entomological Museum of Stanford University. It was taken on the Stanford Estate, near the University. The rest of my material was taken in the foothills in this vicinity, in the ravines of the mountains west (not above 400 feet elevation, however), at Oceanview, San Francisco Co., and in the gullies of the pine forest on the Monterey Peninsula, it being the only trapdoor spider I have yet found there. Also a cast skin was taken from an abandoned burrow near Alum Rock, east of San Jose. It is the least common trapdoor species about Stanford, but abundant in its limited range near Pacific Grove. I have not yet secured a male.

The range of variation in intensity of color is correlated with the light relations of the environment and cannot be considered as of specific value. I have studied carefully the series before me, and while considerable variation exists between various extremes, selected with respect to certain variable characters (such as color, eye relations, thoracic pit, labial spinules, sternal impressions, etc.), I can find no definite set of differences constant enough to warrant specific separation of any two types amongst this material. Those situated in the open average much lighter in color, while those from the shades of the forested ravines are darkest in pigmentation. This species appears to be closer to A. clathratus than to A. atomarius.

The burrow is much shorter than in Eutychides versicolor and relatively of greater diameter, in proportion to the size of the spider. The silk lining is thicker and whiter than in the other genus. Three specimens had branches of the surface type, not true lateral chambers. Above-ground extensions are common, especially at Pacific Grove, and the variations described for E. versicolor might be repeated here, it being practically impossible to distinguish between the "turrets" and traps of the two species, as to appearance and variable structure. The proportions of the burrow and the thickness of the silk tube are to me the only clue to the identity of the genus before the occupant is reached. The largest burrow, that of No. 137, gave the following dimensions: length, 20 cm.; average diameter, 15 mm.; trapdoor, 22 x 17 mm., of soil, moss and grass-bits, and a small leaf. Some of the burrows are surprisingly short, being only 10, or even 6, cm. long.

Number 137 was taken Oct. 31, 1907, and had some sixteen or more young, about 5 mm. long, running about in the deeper end of the tube. Fourteen of these were brought into the laboratory and placed in vials. Most of these burrowed into the soil at once and made little trapdoors about 3 to 4 mm. wide. They were not properly cared for, but, almost two months after being brought in, they replaced their doors when same were removed.

It may be noted here that these young, direct from the mother's burrow, both in this species and in E. versicolor, are readily referable to their respective genera by the characters of the cephalothorax and the abdominal markings; while the sternum, pedipalps and legs give no clue to the genus to which the specimen belongs. This is significant, if the characters earliest established in ontogeny are of most importance in classification.

Eurypelma californica Auss. Verh. zool.–bot. Gessell. Wien., 1871, p. 214.

(Plate XVII.)

The genus Eurypelma is found in California at least as far north as San Mateo County, in the outer Coast Ranges. It used to be common about Stanford University, a few specimens being deposited in the entomological collections here, but it seems to be rare or local about here now. One or two are picked up and brought in almost every year, two large ones having been taken this year—one, a male, picked up while crossing a road (October), the other, a female, found under a rock on the top of one of the

foothills behind the University (March). Many a days' search thru the lowlands and over the foothills, during the last ten months, had left me without finding a single specimen. Just recently, however, my friend, Wm. F. Derby, discovered two local colonies on Jasper Ridge, amongst the foothills, some three miles west of the University, and brought in a live female to prove his find. Returning to one of these colonies together, we secured several specimens, all females, and noted carefully the nesting habits.

I have before me one male from Ventura Co., three from San Diego (San Jacinto), three from Santa Clara Co., and one from Madera Co. (North Fork), also several females, including fifteen from the Jasper Ridge colonies, none of the females having been studied to any extent, however. In addition to these is an interesting series of seven small males and two females from Fort Wingate, N. Mex., kindly loaned me by Mr. Karl Coolidge, of Palo Alto.

Eight species of Eurypelma have been ascribed to the United States (including Lower California), four of which have been described from the male alone, two from the female alone, only two having both male and female described. Five of these species are attributed to California, only one of which has both sexes described, two known only from the male, two only from the female. Simon, in his "Liste des Especes * * * etc.," gives a key to the males of five species, omiting E. liogaster because the diagnosis given yields no characters not common to all the others he recognizes, and of course E. californica and E. rileyi, the males of which have not been described.

A careful study of my material, with reference to the characters selected by Simon as of greatest importance, does not permit me to determine satisfactorily the species that should be represented in the series, and I prefer to group the Californian specimens under the oldest name, E. californica, until I have opportunity to collect and examine a much larger series, from many localities.

This is the well-known, large hairy tarantula of the South-west. It is popularly known to dig in the ground, altho, according to Simon, few of the Aviculariinae make a true excavation. I find in an old number of Science (1884, III, 62, "Notes and News," p. 467) an interesting note which I will quote, in part. Speaking of Cteniza californica, it says: * * * "its trapdoor nest is usually

placed in museums beside the tarantula (Mygale hentzi), and erroneously labeled as the tarantula's nest. This popular error * * * * is stranger, since the tarantula is usually too large to enter the nest of Cteniza, and **itself makes no nest,** occupying crevices in the ground or under stones, spinning a small web." Perhaps another record of this "popular error" is in Ausserer's remark, after his description of E. steindachneri (Verh. z.–b. G. Wien, 1875, p. 200), which says: "* * * * das Nest, an dessen Grunde das Thier in der Regel sizt, ist circa ein Schuh tief, hat kaum ein Zoll im Durchmesser, und der Deckel passt so genau, dass er mur mit grösster Mühe vom Boden unterschieden werden kann." What Ausserer means by "Deckel" is fully explained on page 128 of his paper, where Eurypelma steindachneri and Cteniza californica are cited, with some other species, as examples of the spiders building a "Korkdeckelnest (Cork-covered nest)."

I am not now ready to believe that any of our Eurypelmas make a trapdoor of any kind. The loose webbing, common at the entrance of the many burrows observed in the Jasper Ridge colonies, is hardly less conspicuous than the open hole. The site of each of these colonies is adobe soil, with much outcroping of rock fragments, in open, grassy spots on the hill-sides. There is no evidence that these spots have ever been cultivated.

The burrows were mostly alongside of rocks, commonly bending under the rock if it was a small fragment; a few burrows were one or two feet distant from the nearest rock. The entrances are sometimes nearly circular, but usually quite irregular in shape, and were more commonly loosely "spun up" than open. The burrows are from 20 to 40 cm. long, very irregular in diameter and form, and exhibited little or no web-lining except near the entrance. They are undoubtedly dug by the spiders. No males were found.

When disturbed and placed out on the ground, these spiders hold the abdomen up, waving the long spinnerets about. Their movements are very sluggish and little fight is shown when disturbed. The elevating of the abdomen may be intended to frighten away the intruder; but as a fine mesh of silk is spun from the active spinnerets as the spider slowly walks along, the real purpose of the action may be to ensnare or discommode an attacking "tarantula wasp" (Pepsis), their worst enemy. Upon continued interference, the abdomen is lowered, the fourth pair of legs raised and their metatarsi rubbed against the posterior portion of the

abdomen above. This peculiar action may be largely responsible for the bare spot on the rear of the abdomen in many specimens. None of the series secured upon Jasper Ridge was so denuded, but several individuals, both male and female, in the other material of the collection here, have such a bare space above the spinnerets. One large male, brought into the laboratory early in the Autumn and kept alive for several months, had a conspicuous bare spot and would rub this spot with its metatarsi IV when disturbed from behind. If worried from in front, however, the first pair of legs would be raised, the whole body slowly swung backwards, followed by a quick spring forward, scarcely over two centimeters, however, bringing down the front legs with considerable force.

Altho I have made no particular study of the matter, as yet, I do not believe that the bare spot on the abdomen has any value as a specific, or other taxonomic, character. While the color characters are quite constant in my Jasper Ridge series, considerable variation exists in the New Mexican series mentioned above.

The first specimen brought in by Mr. Derby was secured by pouring water down the burrow. That these tarantulas come out readily when water is poured into their holes, is a well-known fact in California, and many a small boy and camper finds amusement in the performance, as also in putting two individuals together and having a "tarantula fight."

Brachythele longitarsis Simon (♂) Ann. Soc. ent. Fr., 1891, p. 305; (♀) Actes Soc. Linn. Bord., 1891, p. 319.

(Plate XVIII, figs. 1–2; XIX, fig. 1).

Reported from California, Idaho, and Texas, this form seems to have a wide distribution. It is abundant about Stanford University, San Jose, etc., and seems to hold its own in fields and orchards plowed annually. It is common alike in the valley levels and on open hillsides all thru the hills, at least up to 1600 feet and undoubtedly higher. I secured it in Sonoma County, between Guerneville and Forestville, and in Monterey County, near Carmel. Specimens are in the collection here from San Diego County.

Both sexes of this species are described from immature specimens (i. e., ♀ 19 mm. long, ♂ 15 mm. long), and the original descriptions do not do justice to some of the important adult characters. However, it is evident that Simon has more recently

received larger specimens, and has added (Hist. Nat. des Araign., II, Supp., 1903, p. 964), a few points of great help to one working with mature individuals of either sex. I have before me about fifty specimens, including six males. At least half of the females measure over 30 mm. in length, one of the largest measuring 46 mm. long, cephlx. 17 x 14 mm., abdomen 21 mm. long. The scopula is very thin in half-grown, and smaller, specimens, but very dense in the mature individuals. On tarsi I and II it is uninterrupted, on tarsi III it may or may not be longitudinally bisected by a more-or-less distinct setose line, while tarsi IV have a very prominent row of black setae bisecting the scopula, comparable to that illustrated as characteristic of Ischnocolus and its relatives, but said to be present in Brachythele subcalpetana (loc. cit., I, 1892, p. 180), tho nowhere mentioned in connection with B. longitarsis. Simon has added (loc. cit., II, p. 965) that the density of the scopula varies according to the species, and in the larger (B. longitarsis) it forms under the claws, tufts comparable to the fascicles of the Aviculariinae. This is quite true, and the third claw, readily seen in young specimens, is so well concealed amidst these tufts that only careful dissection will reveal it. It is easily scraped off in trying to scrape away the surrounding hairs. In the male of this species, tibiae I are provided with the obtuse tubercle bearing two unequal, closely contiguous spines. This is also true of a specimen loaned me by Mr. W. F. Allen, of Pacific Grove, the spider coming from a bunch of bananas, shipped in, presumably, from the west coast of Central America. It is evidently of another species, but was not determined beyond the genus.

Our Brachythele does not spin a large flat web, after the manner of the Agelenids, as do the Diplurinae, in general, according to Simon. On the contrary, it digs a deep burrow in the soil, lining only the upper fourth, or less, of the tunnnel with considerable or very little web. Occasionally, however, more or less of a web is spread without the cavity, if the site selected is in very loose soil or in long grass; but usually there is little or no suggestion of an outside web, at least within the limits of my experience. Frequently the mouth of the burrow is "spun up," or closed, with silk, compactly at the surface (Plate XX, fig. 1), or loosely and down for some 5 or 6 cm.; my only explanation for this habit being that the spider has had a full meal and wishes to rest undisturbed. It seems to have no peculiar connection

to moulting or breeding time, as I supposed at first. The burrows enlarge considerably below the upper half, and commonly become nearly horizontal below, with rough, irregular, usually unlined walls, except at egg-laying times,—nests with cocoons usually being well-lined. The "cocoon" is fastened to the roof of the cavern. Egg-laying is probably in early summer, but I have no exact data yet as to the month. Numerous cocoons, found in September and October, contained the exuviae of the young's first moult; but the young were gone in all cases. Over fifty of these exuviae were counted from one cocoon. Cast skins of the adults are commonly found in both occupied and deserted burrows, in the Autumn.

Mating time is in the Autumn, when the males may frequently be found walking about on the surface of the ground. Oct. 30th, a pair were taken from one burrow. The female was met with several centimeters up the tunnel, she being more aggressive than usual. The male was down below, and, unlooked for and unexpected, was injured in one palpus and one leg as I was roughly following the long burrow to its end; but the two were brought alive into the laboratory and put into a spacious cage together. The next day the male was found partially wrapped in silk, with the female standing over his remains, still feeding. Later she dug something of a cavity in the soil of the cage and lined the entrance and vicinity with considerable silk. One male was found alone in a well constructed, rather long burrow. It may not have dug the cavity itself, however, as it may have merely appropriated an abandoned one. Males have been found under rocks and planks.

Brachythele is common on Jasper Ridge, mentioned above in connection with Eurypelma. Mr. Derby and myself being surprised to find a Brachythele at the bottom of a few of the burrows amidst the colony of Eurypelma. Similar soil, etc., only a stone's throw away, contained many Brachytheles, but no Eurypelmas. Hence we had a good chance to compare the nesting habits of the two very different species. In fact, we looked in vain for some external evidence sufficient to identify with certainty the genus of the occupant of the burrow. Altho the burrows of Brachythele undoubtedly average more in length and are not so apt to be close to rocks, so much variation exists as to the depth, various diameters, shape, directions, web-lining, proximity to rocks, etc., that we found it impossible really to know

which species we were digging out until the inmate itself was reached.

When disturbed, Brachythele takes a most spirited attitude of defense and usually grabs quickly and savagely at whatever is thrust toward it. If its fangs can penetrate the object introduced, it holds on tenaciously; but if the object is a hard stick or glass rod and resists the insertion of the fangs, the spider hesitates a moment, then hastily retreats into the darkest corner available. Upon further disturbance, and brought to bay, the animal flops over on its back, and with legs and chelicerae spread, fangs fully extended and often dripping with liquid, awaits an opportunity to get in effective work on its tormentor.

Specimens in captivity go eagerly for water when it is provided after considerable neglect. They spread their chelicerae in sucking up the fluid. They capture and devour individuals of their own kind, as well as others, put in with them. One large female caught and ate a small lizard, of the genus Gerrhonotus, of some twelve centimeters length. Carabid beetles are favorite food and their eletra are commonly found in the burrows out in the field. A large tenebrionid, Eleodes, was placed in a cage with several tarantulas, at different times; but not only does the spider fail to attack the beetle, but it will either walk away from it or permit itself to be literally walked all over by the tenebrionid. This same beetle spent some two months in a cage with a large male of Eurypelma, and is still alive; while a small Scelophorus lizard spent but two or three days in the cage before meeting the fate of its cousin Gerrhonotus.

Brachythele also suffers considerably, in nature, from the attacks of the tarantula hawks, Pepsis.

Atypoides riversi Cambr. Proc. Zool. Soc. Lond., 1883, p. 354.

This species has been well described by Rev. O. P. Cambridge. It has been reported from Berkeley, from Santa Clara Co., and from the San Bernardino Mountains. I find it abundant along shaded streams and in thickets in the foothills and mountains wherever I have been, on both sides of the Santa Clara Valley, between Guerneville and Forestville in Sonoma Co., and in the pine forest of the Monterey Peninsula. It is probably to be found thruout the Coast Ranges of California, in all forested areas, if not also in the Sierras. I have seen no males, but have no reason to question the description and drawings of Cambridge.

The "turrets" are open, no door closing the entrance. Sometimes the edges of the chimney are drawn together with numerous strands of silk, effectually closing the entrance, this being done, apparently, at the pleasure or need of the individual, as in Brachythele, and not being a seasonal habit of the species. The burrow is long and well lined with a white silk tube of about the thickness and whiteness of that of Eutychides versicolor. The tunnels are commonly considerably reduced in diameter for the last two centimeters, making a snug fit for the spider, and here it usually snuggles down tightly when the digging has reached the limit necessary to secure the specimen. Hard soil seems to be preferred by this spider, either sandy or adobe. Tho the upper portion of the nest may be thru loose vegetable mould, the lower portion is sure to be in compact soil. The turret may be supported by grass, etc., or standing alone; it is made of silk within and of soil without, decorated or not with whatever is close at hand, whether as a matter of chance or purpose, a matter of convenience or protective coloration, of adornment or contributing to the strength of the structure, it is not easy to decide. A neat type is one well decorated with moss and leaves, small twigs, etc., and with a pale green rim of bits of the common drooping tree-lichen, Ramelina (Plate XX, fig. 4); another is one with pine-needles fastened all over the exterior, the needles pointing in all directions (Plate XX, fig. 3), common at Pacific Grove.

Several of these spiders were brought into the laboratory and they readily constructed burrows and turrets in normal manner, even using loose moss that was placed near the turrets several days after the completion of the nests.

Young, taken from the nests of the parents, very soon dug each its own burrow and built its chimney, whether put with the mother in one large battery jar, or alone in individual vials. It was very interesting to find them up at the mouths of their tubes, waiting for food material to come along. This was at first only about dusk, but later on was at any time on dark days. Small ants, placed in the jars or vials, were caught and carried into the lower regions of the burrows. Small green aphids were, by one brood especially, eagerly taken from the forceps and carried to their fate. The young spiders would jump out after a passing ant or aphis as far as they could reach, always holding on to the rim of the turret with the claws of the fourth pair of legs. They commonly missed their pray, however, jumping too soon or too

late and often when the insect was considerably out of their reach. A hasty retreat into the tube always followed these efforts to secure a meal.

Aliatypus gen. nov.

As already stated, the finding of the male of Atypoides californica Banks has shown that the species can no longer be referred to that genus; nor can it, in truth, be placed in any other genus now described. Tho the female is quite similar to that of Atypoides riversi, the males of the two species are so different in notable structures that generic separation of the two is quite necessary. The new genus may be known by the following characters:

Cephalothorax rather flat caudad, broader than in Atypoides; thoracic pit short, round; caput lower and more rounded at the summit; eyes about the same, situated on the nearly perpendicular slope of the anterior edge, eye-tuber nearly obsolete except portion bearing anterior median eyes, which is more pronounced in the male; chelicerae in female gibbous at the base above (Plate XV, fig. 6), lower and more rounded than in Atypoides (fig. 7), in male not gibbous basally (fig. 2), and without curved projecting apophysis of Atypoides (fig. 8); abdomen shorter, more rounded, with a sub-triangular glossy spot on the anterior slope above, this spot somewhat fine-setose and with a transverse row of much larger setae, normally four in number, on its posterior edge (glabrous in Atypoides), post-abdomen well above spinnerets, which are much stouter, with shorter thicker joints, the outer inferiors nearly as large as the inner; sternum much larger, with six impressions, the anterior pair often so close to the margin as to be hidden by coxae I; labium much wider than long (figs. 1 and 5); coxae of pedipalps, in male, with a short lobe at the cephalo-distal corner (fig. 1), almost as in Hexura (Simon: Hist. Nat. des Ar., II, p. 971, fig. IIII), coxae P in female hardly different from same sex of Atypoides, pedipalps of male (fig. 3) as long as legs I, relatively twice as long as in Atypoides (fig. 9), bulb with long slender conductor; legs robust, many spined.

The generic name is derived from alius and Atypus, signifying "a different Atypus."

It is interesting to note that the pronounced gibbosity at the base of the chelicerae above in the female of Atypoides (fig. 7), is in the male exaggerated into a long, curved projection (fig. 8); while the homologous, but less pronounced, gibbosity of the female of Aliatypus (fig. 6) is almost obsolete in the male of that

genus (fig. 2). In the length of the pedipalps, the male of Atypoides is of the more common type; while Aliatypus is conspicuous for the great elongation of certain segments of those organs (cf. figs. 3 and 9).

Aliatypus californicus, Banks. (Atypoides). Jour. N. Y. Ent. Soc., IV, 1896, p. 88.

(Plate XV, figs. 1–6; XIX, figs. 3–4).

Adult ♂ (Plate XIX, fig. 3)—Length 12 mm., cephlx. 5 x 4 mm., abdomen, about 5 mm. long. Cephalothorax shiny, glabrous, excepting the margins which are minutely black-setose, coarser than in female, pale yellow, paler than in female, the median line and borders of the caput olive-tinted; anterior eyes closer together and eye-tuber a little more projecting than in female; chelicerae very slender, not gibbose at the base as in female, but the inner edge swollen into a rounded setose ridge anteriorly; abdomen grayish, finely black-setose and with scattered much larger black setae, fewer and more scattered than in female; sternum glossy flesh-color, darker and yellow in female; pedipalps as long as legs I, coxae with small lobe, trochanters twice as long as wide, femora and patellae reddish, femora very long and slender, longer than femora I, nearly straight, conspicuously black-setose below on the apical half, patellae long, club-shaped, long-setose below on apical half, tibiae the same, but longer and gibbous below near the apex (Pl. XV, fig. 3), tarsi of generalized type, bulb (fig. 4) very angular, black basally, opaque glossy white below, the broad, flat, angular spine reddish, a very slender, blackish conductor extending out along edge of spine, almost to its suddenly contracted tip; legs more slender than in female, coxae and femora pale flesh-color below, trochanters and rest of leg-segments yellowish, tarsi and metatarsi conspicuously long and slender. (Described from my Nos. 98 and 100).

I will not add further to Banks' description of the female. I have collected some fifty individuals, the largest measurin mm. long.

I have not yet found this spider outside of the foothills and mountains on each side of the Santa Clara Valley, Santa Clara and San Mateo Counties, but it is probably not at all limited to such a small range. Mr. R. W. Doane secured the type material on Black Mountain, Monto Bello Ridge, of the Santa Cruz Ranges. It is common at Alum Rock Park and in the Mt. Hamilton Range at least up to 2900 feet elevation. It is a trapdoor species and seems to have a decided preference for fine compact sandy soil, especially where exposed along streams, roadside banks, etc. Where found it is usually very common. Occasionally it is found in sandy adobe. It is commonly associated with Eutychides and Atypoides.

The burrow is comparatively long, simple, with simple trapdoor. I have seen no evidences of branches of any type, nor any suggestions of extensions above the surface. The silk lining is so meagre as to be practically indiscernible. The banks usually have little or no vegetation upon them other than short scattered moss, and the traps usually are of soil and silk only, or with a few

bits of moss or grass on the outside. Burrows found in dry exposed banks, from September until the first rains in December, had the traps plastered down firmly with soil. A few along flowing streams in the shaded redwood ravines were not so closed, tho in a roadside bank, only a few rods up the canon side, all the nests were plastered up. At the bottom of a nest, so closed, was always a spider, in more or less dormant condition. Doors sealed up in this way are harder to see, as a rule, than when normally fastened at the hinge only. Many of the burrows were found by mere accident, as it were, in digging promiscuously, or following out the burrow of something else. The burrows of small specimens are not easy to distinguish from those of certain mining bees, tiger beetles, etc., if the trap is left out of the comparison. None was found with sealed doors from the end of December to the end of April. No observations were made during May, but all nests found during June had the traps firmly plastered down as in September and October. Undoubtedly this hibernating period is coincident with the dry season of the Californian coast. The dimensions of two of the largest nests examined are: No. 199 trap 21 x 15 mm.; burrow 16 cm. long, nearly straight, outer half 15 mm. diam., inner half 20 mm. No. 203, trap 18 x 13 mm.; burrow 25 cm. long, 18 mm. diameter, with two decided bends.

CONCLUSIONS.

It is evident that the knowledge of our West Coast Araneae theraphosae is far from perfect, and much interesting work is yet to be done. The taxonomic work is yet none too satisfactory and many gaps in the life histories are waiting to be filled in. Questions in distribution must be many and extensive, as only two forms are reported from Washington and Oregon, with one record between there and Mariposa County, California. Nevada seems to have not a single record, and Idaho has but two. Even in the South-eastern States the situation seems to merit considerable attention, and in the South-west the genus Eurypelma is a study in itself. While there are probably many taxonomic questions awaiting the attention of students, it is very apparent that conclusions reached in the laboratory should be based upon as large series as possible and accompanied by extensive field observations; for I find, in certain of the species discussed above, variations comparable to specific differences claimed by some authors.

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The photographs presented herewith were taken by Mr. R. W. Doane, mostly from preserved material. The drawings are original, with the exception of figs. 8 and 9 of Plate XV, which two are copied from Cambridge.

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EXPLANATION OF PLATE XIII.

Eutychides versicolor ♀ (Figs. 1–18), ♂ (Fig. 19)

Fig. 1—Sternum and labium, No. 195.
Fig. 2—Sternum and labium, No. 234.
Fig. 3—Sternum and labium, No. 60.
Fig. 4—Sternum and labium, No. 162.
Fig. 5—Sternum and labium, No. 200.
Fig. 6—Sternum and labium, No. 193.
Fig. 7—Cephalothorax, lateral aspect, No. 234.
Fig. 8—Cephalothorax, lateral aspect, No. 128.
Fig. 9—Dorsal abdominal markings, heavy, No. 195.
Fig. 10—Dorsal abdominal markings, light, No. 234.
Fig. 11—Cephlx. and chelicerae, dorsal aspect, No. 123.
Fig. 12—Cephlx. and chelicerae, dorsal aspect, No. 60.
Fig. 13—Labium, No. 164.
Fig. 14—Labium, No. 163.
Fig. 15—Fang and rake of chelicerae, from below, No. 273.
Fig. 16—Fang and rake of chelicerae, from within, No. 273.
Fig. 17—Fang and rake of chelicerae, from below, No. 128.
Fig. 18—Fang and rake of chelicerae, from within, No. 128.
Fig. 19—Genital bulb left, two views, No. 269.

Aptostichus stanfordianus ♀ (Figs. 20–31.)

Fig. 20—Fang and rake of chelicerae, from within, No. 120.
Fig. 21—Fang and rake of chelicerae, from below, No. 181.
Fig. 22—Labium, No. 179.
Fig. 23—Labium, No. 120.
Fig. 24—Labium, No. 137.
Fig. 25—Cephlx. and chelicerae, dorsal aspect, No. 213.
Fig. 26—Dorsal abdominal markings, heavy, No. 213.
Fig. 27—Dorsal abdominal markings, light, No. 102.
Fig. 28—Cephalothorax, lateral aspect, No. 213.
Fig. 29—Sternum and labium, No. 213.
Fig. 30—Sternum and labium, No. 266.
Fig. 31—Sternum and labium, No. 177.

Aptostichus atomarious ♀ (Fig. 32).

Fig. 32—Sternum and labium, No. 209.

EXPLANATION OF PLATE XIV.

Eutychides versicolor ♀ (Figs. 1–16).

Fig. 1—Tarsal claws, leg IV, inner faces, No. 110.
Fig. 2—Tarsal claws, leg I, outer faces, No. 110.
Fig. 3—Tarsal claws, leg II, inner faces, No. 60.
Fig. 4—Tarsal claws, leg IV, inner faces, No. 60.
Fig. 5—Eye tuber, lateral aspect, No. 195.
Fig. 6—Eye tuber, lateral aspect, No. 128.
Fig. 7—Eye tuber, lateral aspect, No. 234.
Fig. 8—Eye tuber, caudal aspect, No. 128.
Fig. 9—Eyes (anterior row above), No. 200.
Fig. 10—Eyes (anterior row above), No. 229.
Fig. 11—Eyes(anterior row above), No. 151.
Fig. 12—Eyes (anterior row above), No. 234.
Fig. 13—Eyes (anterior row above), No. 131.
Fig. 14—Patella of leg III, anterior face, No. 195.
Fig. 15—(P) Tarsus of pedipalps, No. 60.
(I) Tarsus and metatarsus of leg I, No. 60.
Fig. 16—Coxa of pedipalp, ventral face, No. 60.

Aptostichus stanfordianus ♀ (Figs. 17–29).

Fig. 17—Coxa of pedipalp, ventral face, No. 120.
Fig. 18—Patella of leg III, anterior face, No. 120.
Fig. 19—Eyes (anterior row above), No. 137.
Fig. 20—Eyes (anterior row above), No. 213.
Fig. 21—Eyes (anterior row above), No. 187.
Fig. 22—Eye-tuber, lateral aspect, No. 137.
Fig. 23—Eye-tuber, lateral aspect, No. 213.
Fig. 24—Eye-tuber, caudal aspect, No. 137.
Fig. 25—Tarsal claws, leg I, inner faces, No. 120.
Fig. 26—Tarsal claws, leg II, inner faces, No. 120.
Fig. 27—Tarsal claws, leg III, inner faces, No. 120.
Fig. 28—Tarsal claws, leg IV, inner faces, No. 120.
Fig. 29—(P) Tarsus and "tibia" of pedipalp, No. 228.
(I) Tarsus and metatarsus of leg I, No. 228.
(II) Tarsus and metatarsus of leg II, No. 228.

Aptostichus atomarius ♀ (Figs. 30–32.)

Fig. 30—Eye-tuber, caudal aspect, No. 209.
Fig. 31—Eye-tuber, lateral aspect, No. 209.
Fig. 32—Eyes (anterior row above), No. 209.

EXPLANATION OF PLATE XV.

Aliatypus californicus (Figs. 1–6).

Fig. 1—Ventral aspect of ♂ (abdomen omitted), No. 100.
Fig. 2—Lateral aspect of ♂, No. 100.
Fig. 3—Pedipalps of ♂, No. 100.
Fig. 4—Genital bulb, four aspects, showing "conductor" in "c" and "d", No. 100.
Fig. 5—Ventral aspect of ♀ (abdomen omitted), No. 32.
Fig. 6—Lateral aspect of ♀ (abdomen omitted), No. 32.

Atypoides riversi (Figs. 7–9.)

Fig. 7—Lateral aspect of ♀ (abdomen omitted), No. 317.
Fig. 8—Lateral aspect of ♂ (after Cambridge.)
Fig. 9—Pedipalp of ♂ (after Cambridge.)

EXPLANATION OF PLATE XVI.

Fig. 1—Eutychides versicolor ♀
Fig. 2—Eutychides versicolor ♂
Fig. 3—Aptostichus atomarius ♀.
Fig. 4—Aptostichus stanfordianus ♀ (under alcohol).
Fig. 5 -Aptostichus stanfordianus ♀ (regenerated leg I).

EXPLANATION OP PLATE XVII.

Fig. 1—Eurypelma californica ♂
Fig. 2—Eurypelma californica ♀.

EXPLANATION OF PLATE XVIII.

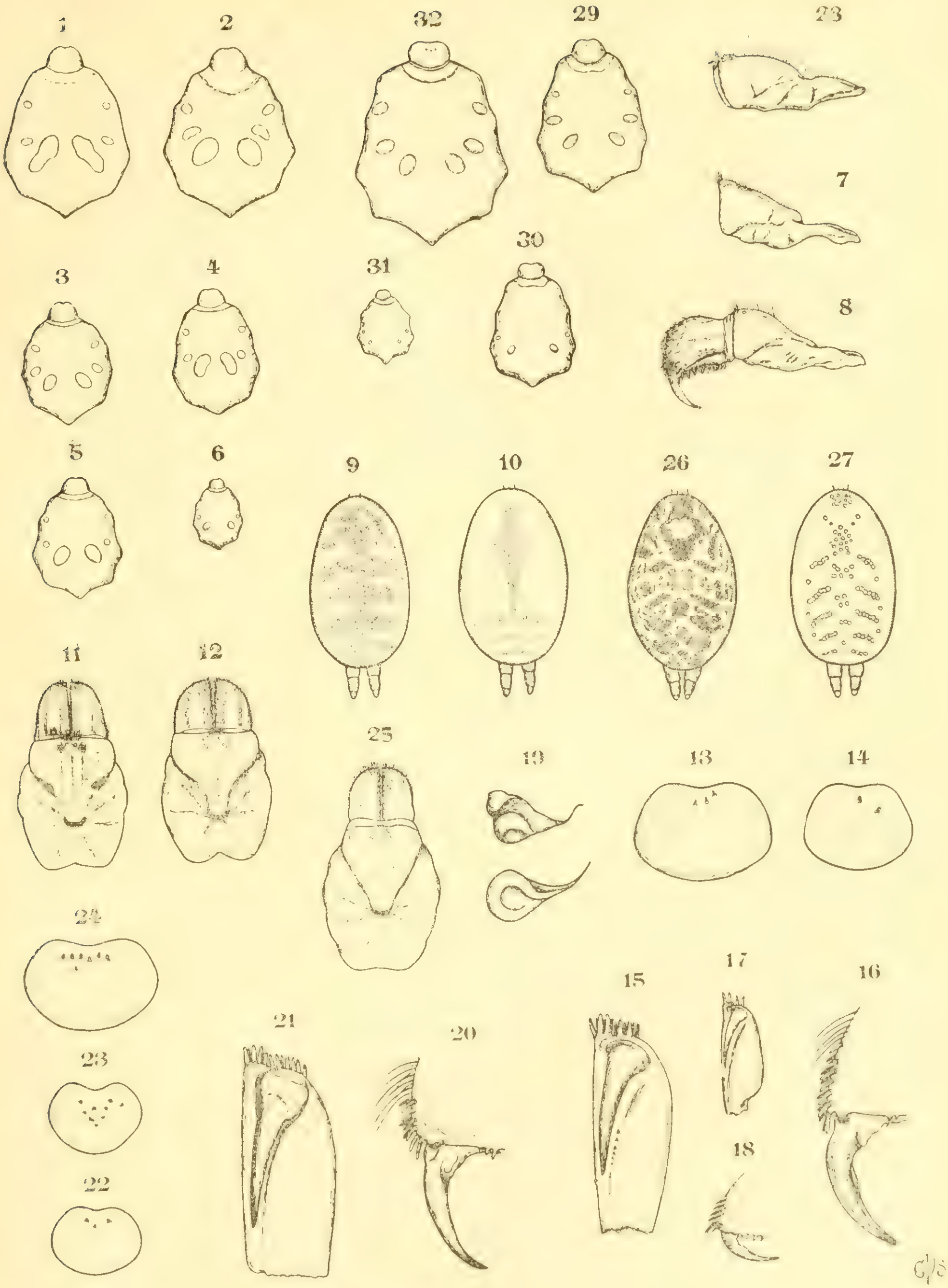
Fig. 1—Bracyhthele longitarsis ♂ (regenerated palpus).
Fig. 2—Brachythele longitarsis ♀ (regenerated leg I).

EXPLANATION OF PLATE XIX.

Fig. 1—Brachythele longitarsis ♀ (from life).
Fig. 2—Atypoides riversi ♀.
Fig. 3—Aliatypus californicus ♂.
Fig. 4—Aliatypus californicus ♀.

EXPLANATION OF PLATE XX.

Fig. 1—Brachythele longitarsis, web-covered hole.
Fig. 2—Brachythele longitarsis, open hole in grass.
Fig. 3—Atypoides riversi, turret with pine-needles.
Fig. 4—Atypoides riversi, turret with moss, etc.



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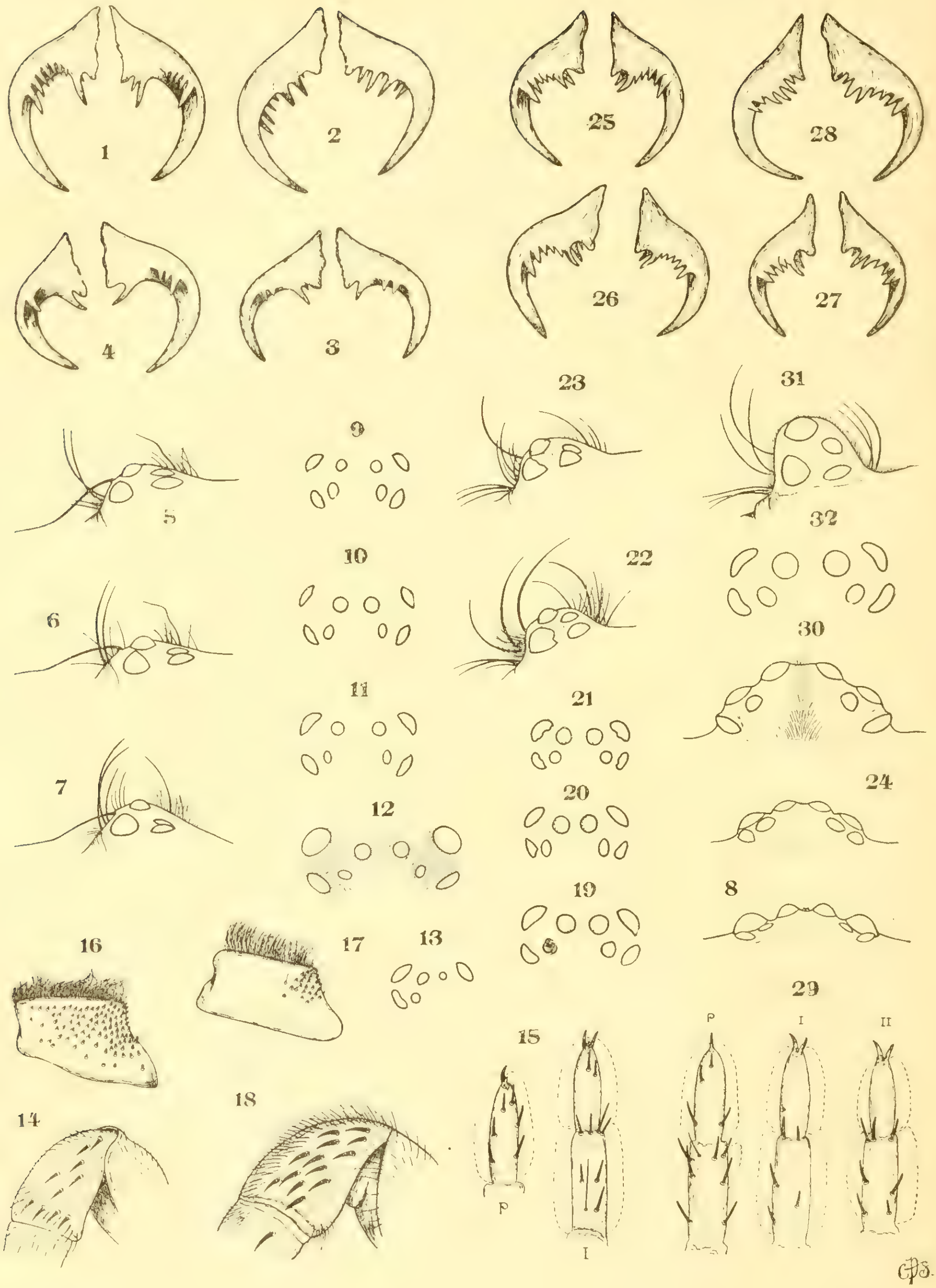
C. P. Smith.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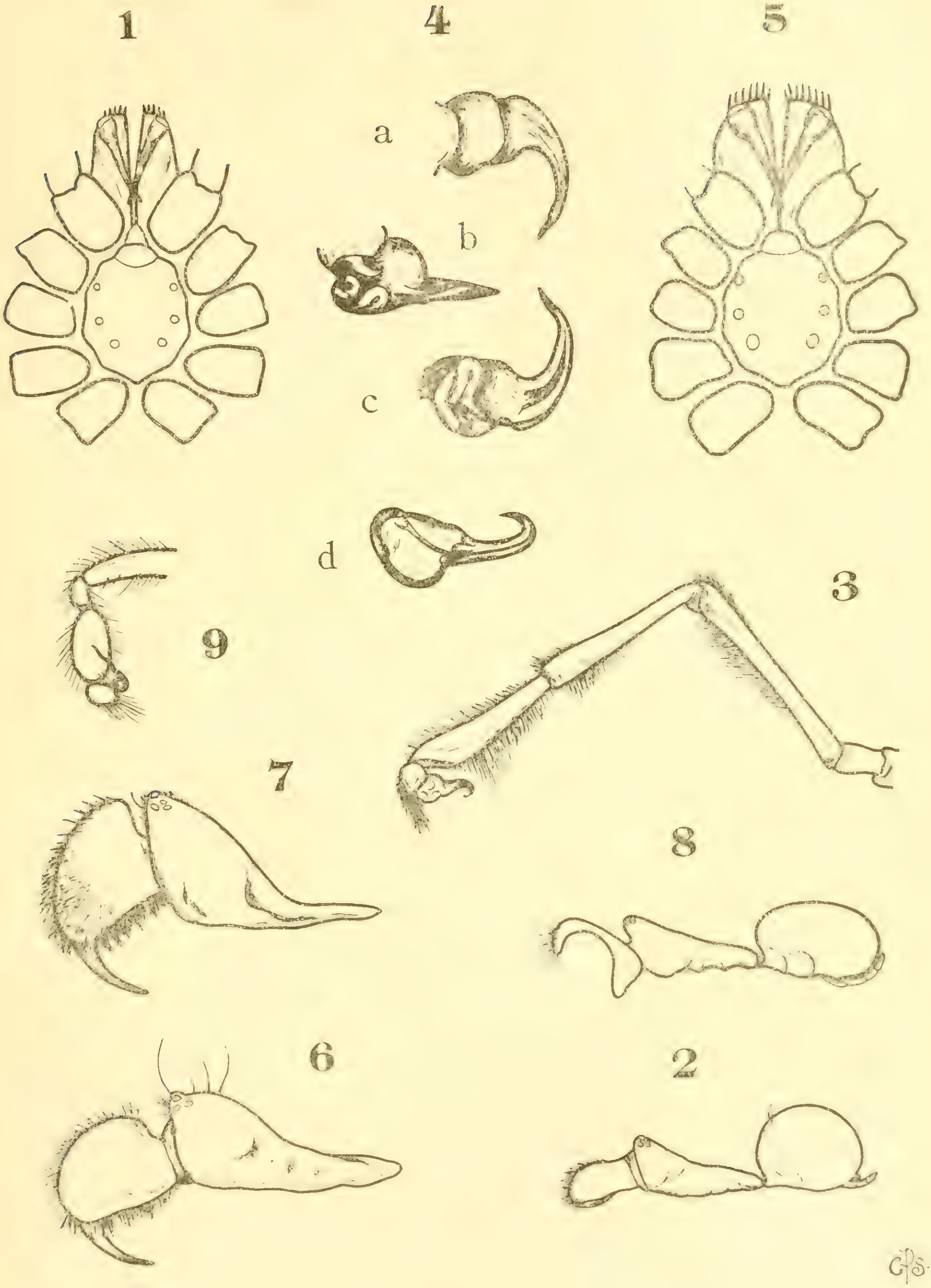

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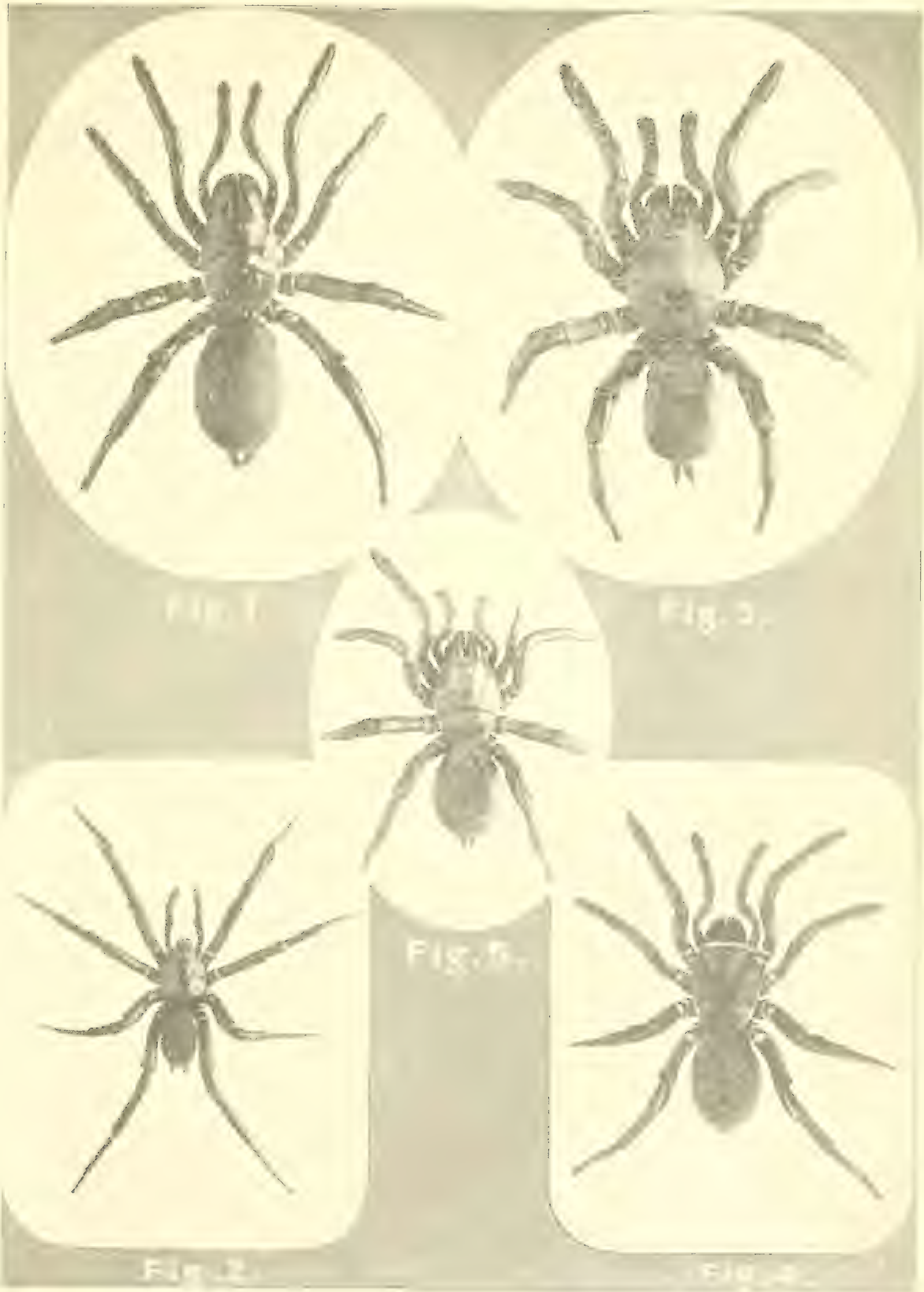

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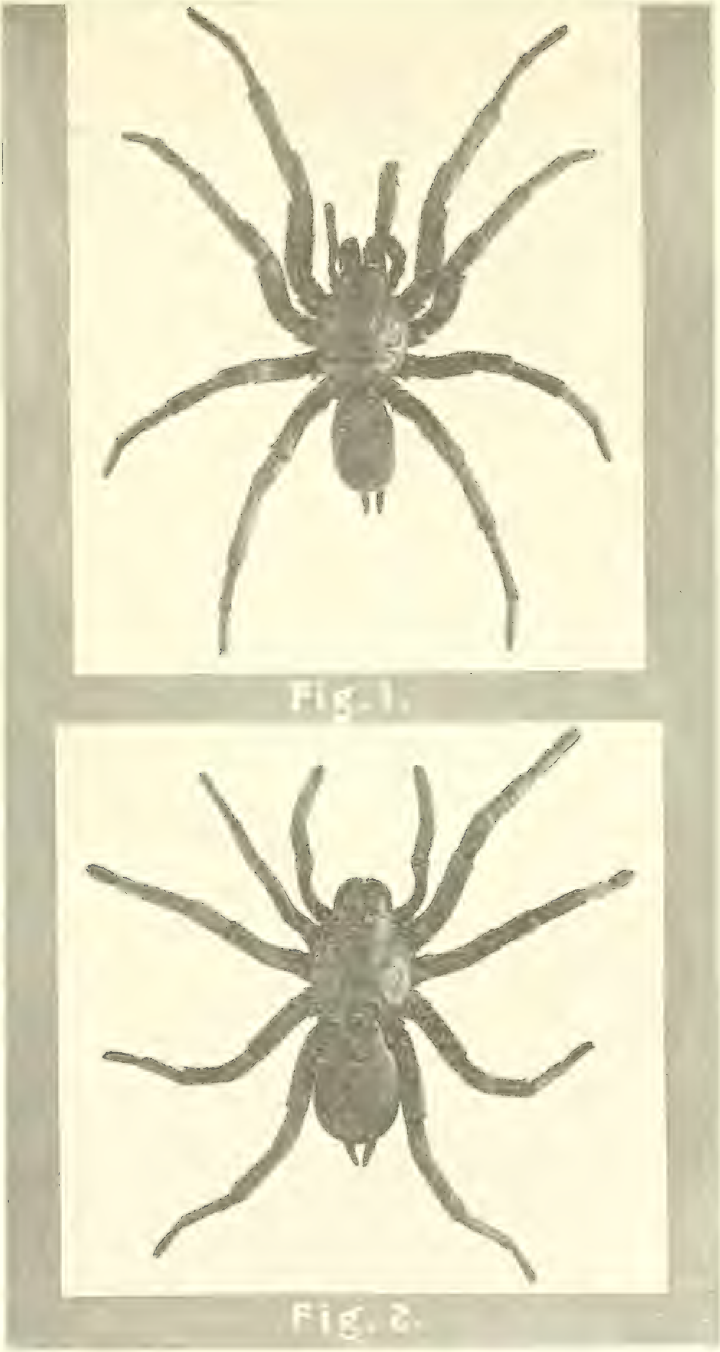
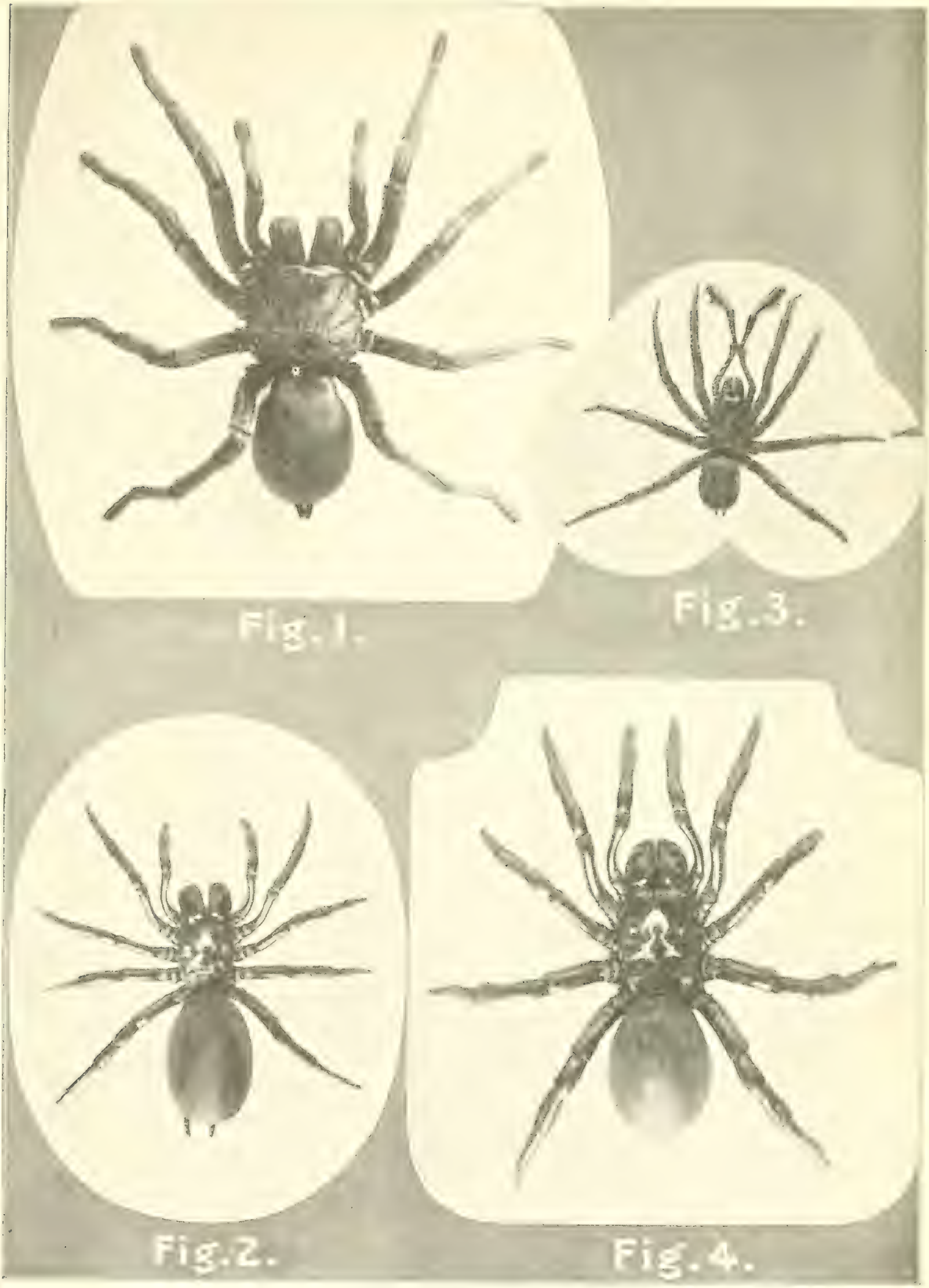


C. P. Smith.

Fig. 1.

Fig. 2.

C. P. Smith.



C. P. Smith.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

C. P. Smith.

STUDIES ON APHIDIDÆ. I.*

By John J. Davis,
OFFICE OF THE STATE ENTOMOLOGIST, URBANA, ILL.

Myzus elæagni Del Guercio.

I first found this aphid at Urbana, Ill., November 16, 1907, common on the ornamental Russian olive tree (Elæagnus angustifolia). At that time only the sexual forms (wingless oviparous females and winged males) and the jet-black eggs were found, the latter being common on the branches, along and in the axils of the buds. A week later the same species was found on Shepherdia argentea.

Early this year (January 18, 1908) a branch of Elæagnus bearing many eggs was placed in a warm insectary, the branch being placed in water to keep it fresh. These eggs were first noticed hatching February 2, fifteen days after being brought into the warm room, and at about the same time at which the leaf-buds began to expand. (The temperatures, taken with a thermograph at midnight, 6 A. M., noon, and at 6 P. M., gave an average of 59.2° F. for the period between the time the eggs were brought into the insectary until they commenced hatching.) In the warm insectary, the stem-mothers, or fundatrices, were first observed producing young February 14, and on February 21 the first migrants of the second generation were found. These migrants would usually fly from the original food plant immediately upon becoming winged, and this, with the fact that I have never found it on Elæagnus during the summer, and that Professor C. P. Gillette has collected it on thistle, indicates that this aphid has a regular alternate food plant.

Myzus elæagni was first found in Europe and described by Doctor Del Guercio in Il Naturalista Siciliano, Vol. XIII, p. 197 (1894). I have not seen the original description, nor have I examined European specimens, but specimens from Illinois were sent to Doctor Del Guercio, who kindly determined them as his M. elæagni. In the Canadian Entomologist, Vol. XL., p. 17 (1908),

* The object of these studies has been to learn the winter histories of little-known species of Aphididæ, and to describe the various sexual forms heretofore unpublished; also to redescribe species which may have been only briefly described.

Professor Gillette described this species as M. braggii. His specimens were collected on Canada thistle (Carduus arvensis), and he has since written me that he also collected it this spring (1908) on Elæagnus, and that he had found it on this tree only in the spring previous to July 1, which agrees with the observations of Mr. J. T. Monell and myself. Mr. Monell sent me specimens of a Myzus on a hardy Elæagnus which proved to be of the same species as those collected in Colorado and Illinois. These specimens were collected May 10–13, 1907, at St. Louis, Mo., and Mr. Monell writes that he has not found it after that date. This year (1908) I first found winged migrants on Elæagnus at Chicago, Illinois, September 17, and each had given birth to several young of the sexual generation.

DESCRIPTION.

Under the name, Myzus braggii, n. sp., Professor C. P. Gillette has described (Canadian Entomologist, January, 1908) the winged male, and winged and wingless viviparous females, and further descriptions of these stages are unnecessary.

"Winged viviparous female, second generation from egg.—(Bred on Elæagnus angustifolia)—Head dusky; on the front and between the bases of the antennæ are a few capitate hairs, and also a conspicuous prominence bearing the cephalic ocellus; the frontal (antennal) tubercles slightly gibbous. (Pl. XXI, fig. 6.) Antennæ dusky to black, excepting the two basal segments, which are concolorous with the head; irregularly placed sensoria as follows: 14–39 (usually 25–35), on III., 7–17 on IV., 4–7 on V., and several smaller ones at the distal end of the basal portion of VI.; subequal to the body in length; the first segment gibbous. (Pl. XXI, fig. 3.) Eyes dark red. Beak dark at tip, and not reaching beyond the coxæ of the second pair of legs. Thoracic plates light to darker brown. Wings hyaline, the first and second discoidals usually branching at about one half or slightly less, the distance from the margin to the third discoidal. (Pl. XXI, fig. 1.) Legs dusky and with a greenish tint, excepting the articulations, which are darker, and the apical ends of the tibiæ and the tarsi, which are black. Abdomen pale greenish, or yellowish green, with a darker quadrangular blotch on the dorsum. Cornicles with the distal third incrassate; pale and almost transparent, excepting the incrassated portion, this being dusky; extending beyond the tip of the abdomen. (Pl. XXI, fig. 8.) Style pale and with a greenish tint, more or less ensiform in shape, and about equal to the hind tarsus in length.

Measurements.—(The extreme, as well as the averages, from many specimens measured, are given.) Length of body, 1.23 – 1.52 mm.; width, 0.472–0.509 mm.; length of wing, 2.00–2.50 mm.; width, 0.72–0.90 mm.; wing expanse, 4.70–5.60 mm.; antenna, I, 0.0652; II, 0.0489; III, 0.2771–0.4075, average, 0.3317; IV, 0.1467–0.2445, average, 0.2021; V, 0.1304–0.2282, average, 0.1793; VI, basal, 0.0815–0.0978, average, 0.0896; VI, filament, 0.4401–0.6909, average 0.5676; average total, 1.4844; mm. cornicles, 0.2445–0.3586, average, 0.3015 mm.; style, 0.0978 mm.; tarsus, 0.0978 mm.

Wingless viviparous female.—(Reared from eggs collected on Elæagnus angustifolia). General body color cream yellow, the thorax and abdomen with two longitudinal rows of more or less oblong, bright green markings. Head with a number of capitate hairs projecting from the front. The two basal segments of the antennæ almost clear transparent or with a slight greenish tint; the others, except the last two segments, which are dusky, are pale green.

Antennae not more than one half the length of body; borne on gibbous tubercles; the first segment gibbous and with a single capitate hair projecting from the prominence; the articulation between the third and fourth segments absent or indistinct in the specimens reared in the insectary. (Pl. XXI, fig. 5.) Eyes dark red. Beak not reaching beyond the coxæ of the middle pair of legs. Coloration of legs as follows: femora light green, tibiæ pale greenish, excepting the tip, which is slightly dusky; tarsi black. The last two segments of the abdomen with a number of capitate hairs projecting caudad. Cornicles almost transparent and with a faint greenish tint, incrassate, and reaching to the tip of the abdomen. Style pale green, and ensiform in shape. (Pl. XXI, fig. 7.)

Measurements.—(Averages.) Length of body, 1.6119 mm.; width, 0.7898 mm.; antenna, I, 0.0631; II, 0.0368; III and IV, 0.3390; V, 0.1450; VI, basal, 0.0896; VI, filament, 0.2445; total, 0.9180 mm.; cornicles, 0.3912 mm.; style, 0.1630 mm.; tarsus, 0.0978 mm.

Immature.—The young when first hatched from the eggs are brown, with a slight tint of dull orange, and they very closely resemble the rusty leaf patches, present, at this stage of development, on the Elæagnus leaves. The young of the second instar of this fundatrix generation are pale yellowish green, and of about the same color as the leaves, the latter by this time having lost most of the brownish patches and become more of a solid pale green color. This would appear to be a case of protective resemblance.

Wingless oviparous female.—Head pale green, and bearing a few capitate hairs on the front. Antennæ borne on gibbous tubercles, and the first segments likewise gibbous; dusky, excepting the first two segments and the basal portion of the third, which are pale green; usually reaching to the bases of the cornicles; the usual circular sensorium at the distal end of V, and several at the apex of the basal portion of VI; the articulations of the third and fourth segments indistinct, and sometimes invisible. (Pl. XXI, fig. 4.) Eyes dark red. Abdomen and thorax of the general dark coloration, having a mottled appearance and consisting of greens, reds, and blacks; and bearing a few capitate hairs. Under magnification there appear three more or less distinct longitudinal lines of this dark color mixture on the dorsum, one on the median line and one on either side; also, the last few segments are solidly of this color. Legs pale green, excepting the articulations and the tarsi, which are dark to black; the basal two thirds of the hind tibiæ swollen and bearing numerous circular sensoria. (Pl. XXI, fig. 9.) Cornicles incrassate, and reaching to tip of abdomen; pale green, and darkening at tips. Style ensiform and of a pale dirty-green color.

Measurements.—(Averages.) Length of body, 1.6726 mm.; width, 0.8363 mm.; antenna, I, 0.0652; II, 0.0489; III, 0.2445; IV, 0.1483; V, 0.1597; VI, basal, 0.0880; VI, filament, 0.4939; total, 1.2405 mm.; cornicles, 0.3830 mm.; style, 0.1711; mm. tarsus, 0.0978 mm.

Young of the first three instars are light green in color, but the immature aphids of the fourth instar are pale yellow with bright green spots scattered over the body in longitudinal rows, as are the dark markings in the adult.

Eggs.—Elliptical oval, greenish-yellow when first deposited and later changing to jet-black, and measuring 0.2443 by 0.5216 mm.

Winged male.—(No color notes were made and the following description is taken from specimens mounted in balsam.) Antennæ longer than body; borne on gibbous tubercles; the first segments likewise gibbous; irregularly placed circular sensoria as follows: 24–27 on III, 9–14 on IV, 2–4 on V, and several at the distal end of the basal portion of VI. (Pl. XXI, fig. 2.) Wings hyaline, the first and second discoidals branching about one third, or slightly more than one third, the distance from the margin of the wing to the third discoidal. Cornicles incrassate, and reaching beyond the tip of the abdomen. Style ensiform.

Measurements.—(Average.) Length of body, 1.2089 mm.; width, 0.6045 mm.; antenna, I, 0.0652; II, 0.0571; III, 0.4401; IV, 0.3097; V. 0.2553; VI, basal, 0.0978; VI, filament, 0.8150; total, 2.0402 mm.; cornicle, 0.3830 mm.; style, 0.1630 mm.; hind tarsus, 0.1141 mm.

The Barberry Plant-louse (**Rhopalosiphum berberidis** Kaltenbach)

Rhopalosiphum berberidis Kalt. was first noted and described as new in this country in 1851 by Asa Fitch, in his "Catalogue of the Homoptera of New York." He later gave the complete life history of the species, under the name of Aphis berberidis Kalt., in the "Tenth Report of the Insects of New York." It has also been mentioned in the writings of Walsh, Thomas, Oestlund, and Hunter, but has never been reported outside of New York.

Mr. J. T. Monell has kindly sent me specimens of this species, collected by him in St. Louis, Mo., and I have frequently found it in Illinois. Mr. Paul Hayhurst writes that he has found it common in Massachusetts.

Fitch reported it from Berberis vulgaris, this being likewise the only known food plant in Illinois. In Europe it was found by Kaltenbach on Berberis vulgaris, and by Buckton on B. communis.

I first found this aphid at Urbana, Ill., about the middle of June, 1907, on the stems and on the undersides of the leaves of Berberis. It continued to be very abundant until about the first of August, when it became comparatively scarce, although at no time during the entire summer were the plants free from this aphid. During October they again became numerous, and November 14 I found the sexual forms, although at this time most of them were immature. On this date, eggs also were found, these being deposited in the crevices of the bark and in the grooves between the buds and stem.

This spring (1908) I first examined these plants March 18, and on that date found the eggs all hatched and the reddish-brown immature stem-mothers numerous upon the stems, although the buds had not yet opened. Eggs of a number of other aphids were observed this spring, but those on the Berberis were the first to hatch, the eggs of the other species not hatching until about a week later.

Adult stem-mothers were first noticed March 25, and the first winged adults of the second generation eight days later, April 2. Although most of the second generation became winged, many were wingless upon becoming adult. The immature individuals, as well as the adults of this first generation differ in coloration from the immature and adults of the succeeding generations, as will be seen from the following descriptions

DESCRIPTIONS.

Wingless viviparous female, stem-mother.—General appearance, to the naked eye, orange. Head and thorax almost entirely bright orange. Antennæ white or nearly so, excepting the tips, which are dusky. Legs concolorous with antennae, excepting the tarsi, which are dark. Abdomen with two lateral, longitudinal stripes of orange, the central dorsum pale greenish or yellowish with longitudinal streaks of orange, the last three abdominal segments entirely orange. Cornicles pale whitish, except the extreme tips. Style orange-yellow. Otherwise as the wingless viviparous females of the succeeding generations, excepting the measurements of the total length and width, the stem-mothers usually being the greater.

The immature stem-mothers (first and second instars) are reddish brown, with dark (almost black) markings, as follows: two longitudinal rows of bars along the median dorsum and only separated by a fine median line of the body color; and two longitudinal rows of spots, one on each of the lateral margins. Head very dark, with a fine median line dividing the dark area into two patches. Antennæ dusky.

The aphids of the fourth instar of the first generation are very similar to the adults in color, except that the markings are not such a bright orange and the body is covered with more or less of a bloom.

Winged viviparous female.—General body color yellow. Antennæ slightly dusky and faintly imbricate; not reaching beyond the bases of the cornicles; segment III subequal to VI (=VI+VII of some authors), segments IV and V subequal and their combined length about equal to that of III, the basal portion and filament of VI subequal; irregularly placed circular sensoria as follows: 18–24 on III, 3–7 on IV, 3–5 on V, and several at the distal end of the basal portion of VI. (Pl. XXII, fig. 15.) Eyes appearing black to the naked eye, but under magnification they appear dark- or red-brown. Ocelli brown and distinct upon the yellow back-ground. Wings hyaline; the first and second discoidals branching at about one-third the distance from the margin to the third discoidal. (Pl. XXII, fig. 12.) Legs pale yellowish, except the tarsi and the distal ends of the tibiæ, which are dusky. Abdomen a paler yellow than the head and thorax. Cornicles concolorous with the body, excepting the distal ends, which are often slightly dusky; reaching to or slightly beyond the tip of abdomen; basal third very narrow and the remaining two thirds strongly incrassate, the tips slightly imbricate and flaring. Style concolorous with the body, conical, and slightly more than one third the length of the cornicles. (Pl. XXII, fig. 13.)

Measurements.—(Measurements from specimens mounted in balsam.) Length of body, 1.40 mm.; width, 0.51 mm.; length of wing, 2.8361 mm.; width, 1.0544 mm.; wing expanse, 5.50 mm.; antenna, I, 0.0652; II, 0.0570; III, 0.3260; IV, 0.1847; V, 0.1901; VI, basal, 0.1548; VI, filament, 0.1662; total, 1.1440 mm.; cornicles, 0.3423 mm.; style, 0.1385 mm.; hind tarsus, 0.1141 mm.

Wingless viviparous female.—(Summer form.) General color bright yellow and often with a slight greenish tint. Antennæ whitish-yellow; the third segment very faintly imbricate and the remaining segments with increasing imbrication; segment III subequal to, or slightly less than, VI (base+filament), IV and V subequal, and their combined length equal to, or slightly greater than, VI.; about one-half the length of the body; the usual sensorium near the apex of V, and several at the distal end of the basal portion of VI. (Pl. XXII, fig. 17.) Eyes red. Legs whitish yellow. Cornicles concolorous with the body; the basal third narrow and the remaining two-thirds strongly incrassate, the tip being more or less flaring; reaching to or slightly beyond the end of the abdomen. (Pl. XXI, fig. 11.) Style concolorous with the body, conical, and between one-half and one-third the length of the cornicles.

Measurements.—(Taken from specimens mounted in balsam.) Length of body, 1.5453 mm.; width, 0.7817 mm.; antenna, I, 0.0652; II, 0.0489; III, 0.1956; IV, 0.1304; V, 0.1355; VI, basal, 0.1110; VI, filament, 0.1418; total, 0.8284 mm.; cornicles, 0.3830 mm.; greatest width of cornicles, 0.0896 mm.; style, 0.1548 mm.; hind tarsus, 0.1222 mm.

Wingless oviparous female.—Head pale dirty green and with a median prominence projecting anteriorly. Antennæ dusky and faintly imbricate; one sensorium near the extremity of V, and several at the distal end of the basal portion of VI; placed on frontal tubercles, and the first segment somewhat gibbous; about one-half the length of the body; (Pl. XXII, fig. 16.) Eyes black. Beak reaching to the coxæ of the second pair of legs. Dorsum of prothorax almost entirely covered with a colored patch, the coloration being a mixture of red, brown, and black, intermixed with lighter colors; other thoracic segments with a similar coloration, but the bars of color are broken along the median line. Legs dusky, excepting the basal halves of the femora, which are pale green; the hind tibiæ very noticeably swollen and bearing many circular sensoria. (Pl. XXI, fig. 10.) The three anterior segments of the abdomen with markings similar to those on the meso- and metathorax; the remaining segments with darker markings which are more or less contiguous, and appear as a large dark patch on the dorsum. Cornicles green at the bases and becoming dusky at the tips, extending almost to the end of the abdomen; and the distal two-thirds strongly incrassate. Style pale dirty green, conical, and less than half the cornicles in length.

Measurements.—(Taken from specimens mounted in balsam.) Length of body, 2.0798 mm.; width, 1.0544 mm.; antenna, I, 0.0733; II, 0.0570; III, 0.2559; IV, 0.1695; V, 0.1768; VI, basal, 0.1255; VI, filament, 0.1532; total, 1.0112 mm.; cornicles, 0.4352 mm.; style, 0.1793 mm.; hind tarsus, 0.1304 mm.

Eggs.—The elliptical-oval eggs are orange-yellow when first laid, but gradually change to a jet black.

Winged male.—Head black and with gibbous frontal tubercles. Antennæ black, except the two basal segments; reaching beyond the tip of the abdomen; segment I gibbous, III the longest, and the last three more or less imbricate; irregularly placed sensoria as follows: 19–29 on III, 5–10 on IV, 5–7 on V, and several at the distal end of the basal portion of VI. (Pl. XXII, fig. 14.) Eyes black. Thoracic plates black. Wings hyaline and with dark veins; the first and second discoidals branching about one third (sometimes varying to one half) the distance from the margin to the third discoidal. Legs dirty yellow, except the articulations, which are dark, and the tarsi, which are black. Abdomen yellow with black transverse bars, the anterior ones being broken along the median line. Cornicles concolorous with the abdomen and darkening towards the apex, extending beyond the tip of the abdomen; distal two-thirds strongly incrassate, and the tip more or less flaring. Style dusky to black, conical, and slightly longer than the hind tarsus.

Measurements.—(Taken from specimens mounted in balsam.) Length of body, 1.2784 mm.; width, 0.5360 mm.; length of wing, 2.5997 mm.; width, 1.0425 mm.; wing expanse, 5.6449 mm.; antenna, I, 0.0652; II, 0.0570; III, 0.4373; IV, 0.2934; V, 0.2836; VI, basal, 0.1752; VI, filament, 0.2315; total, 1.5432 mm.; cornicles, 0.3260 mm.; style, 0.1276 mm.; hind tarsus, 0.1167 mm.

Male pupa.—Entire body pale greenish-yellow. Eyes dark red-brown.

The Yellow Clover Plant-louse (**Callipterus trifolii** Monell).

This yellow Callipterus is common in all parts of Illinois, living solitary, usually on the undersides of the leaves of red clover (Trifolium pratense). C. trifolii was first described by Mr. J. T. Monell in the Canadian Entomologist, Vol. XIV, p. 14 (1882), from specimens collected in Washington, D. C., June 8, 1880. In the literature it has been reported from Iowa (Osborn and Sirrine), and from Delaware (Sanderson). I have received specimens from Mr. Paul Hayhurst, collected in Minnesota, and he writes that he has also found it in Kansas, Minnesota, North Dakota, and Virginia. Mr. Monell writes that he has found it in

Missouri, and Doctor J. W. Folsom found it on clover in New York, July 22, 1908.

Heretofore it has been stated that individuals of the genus Callipterus always become winged before reproducing viviparously. This characteristic does not always hold true for C. trifolii, for I have found wingless individuals giving birth to young. As a rule, however, most of the young are produced by winged individuals.

DESCRIPTIONS.

Wingless viviparous female.—General color of body pale green with a faint yellowish tint, and with dusky tubercular spots on the dorsum. Antennae pale whitish green at base, but becoming dusky and black towards the apex; very faintly imbricate, as long as, or slightly longer than, body, 9–12 sensoria in a row on segment III. (Pl. XXIII, fig. 30.) Eyes dark red. Beak not reaching beyond the coxæ of the second pair of legs. Legs pale, excepting the joints, which are dusky, and the tarsi, which are black. The six longitudinal rows of tubercles as in winged form, excepting that they are more prominent and bear conspicuous capitate hairs. Cornicles and style as in winged individual.

Measurements.—(From specimens in balsam, collected on Trifolium pratense at Urbana, Ill., September 4, 1907.) Length of body, 1.49–1.67, average 1.60 mm.; width, 0.72–0.83, average, 0.76 mm.; antenna I, 0.076; II, 0.053; III, 0.489–0.554, average, 0.517; IV, 0.326–0.375, average, 0.347; V, 0.285–0.342, average, 0.316; VI, basal, 0.146–0.163, average, 0.156; VI, filament, 0.155–0.179, average, 0.162; total (average) 1.627 mm.; cornicles, 0.062 mm.; style, 0.171 mm. hind tarsus, 0.130 mm.

Winged viviparous female.—General color pale yellowish green, with dusky markings on the dorsum. Antennae concolorous at base and darkening towards apex, longer than body, with 10–12 sensoria in a row on segment III, and faintly imbricate. (Pl. XXIII, fig. 29.) Eyes dark red to brown. Beak not reaching to coxæ of second pair of legs. Wings hyaline; veins dark brown to black, with a very narrow border of brownish tint and with a small brown patch at apices of veins, basal half of stigmal vein obsolescent, terminal forks of discoidal branching at a point slightly less than one half the distance from where the discoidal first branches. (Pl. XXII, fig. 20.) Legs concolorous with body, excepting tarsi, which are nearly black. Abdomen with six longitudinal rows of dusky tubercles, three rows on each side of the dorsal median. The tubercles of the two rows on each side of the median are oblong, and each tubercle bears two fine setæ. The other tubercles are more or less circular, and each bears but one setæ. Cornicles (Pl. XXII, fig. 1) and style (Pl. XXII, fig. 21) somewhat dusky, the former tubercular and the latter globular.

Measurements.—(From specimens in balsam, collected on Trifolium pratense at Urbana, Ill., August 25 and September 4, 1907.) Length of body, 1.345–1.564, average, 1.454 mm.; width, 0.582–0.691, average, 0.642 mm.; expanse of wings, 4.654 mm.; length of wing, 2.045 mm.; antenna, I, 0.077; II, 0.055; III, 0.489–0.538, average, 0.516; IV, 0.358–0.391, average, 0.368; V, 0.301–0.358, average, 0.320; VI, basal, 0.146–0.179, average, 0.167; VI, filament, 0.146–0.179, average, 0.162; total (average), 1.665 mm.; cornicles, 0.066 mm.; style, 0.139 mm.; hind tarsus, 0.129 mm.

The following table gives comparisons of the average lengths (in millimeters) of the antennal segments of the type specimens, specimens from Mr. Hayhurst and the Illinois specimens. The measurements of the type specimens and of those collected by Mr. Hayhurst were made by Mr. Monell, who has kindly sent them for my use.

	I	II	III	IV	V	VI basal	VI filament	Total length
Monell's Types, Washington, D. C., June 8, 1880.........	0.057	0.046	0.448	0.312	0.287	0.153	0.135	1.438
Hayhurst's Specimens, Arlington, Va., June 28, 1907.....	0.07	0.050	0.492	0.292	0.264	0.143	0.150	1.461
Davis's Specimens, Urbana, Ill., Aug. 25 and Sept. 4, 1907....................	0.077	0.055	0.516	0.368	0.320	0.167	0.162	1.665

Wingless oviparous female.—General color yellow orange, when fully mature. When they first become adult the body is usually entirely yellow, but as the eggs, which are of an orange color, begin to develop within the body they show through the semi-transparent skin and give the orange tint to the body. Head pale yellow. Antennæ, at base, concolorous with head, and darkening towards the apex; not reaching to base of cornicles, and with about 8 or 10 circular sensoria in a row on segment III. (Pl. XXIII, fig. 32.) Eyes black. Prothorax pale yellow, meso- and metathorax varying from yellow to orange, according to age since maturity. Legs pale yellowish except tarsi; proximal half of hind tibiæ swollen and with 25 to 40 inconspicuous circular sensoria. (Pl. XXIII, fig. 33.) Dorsum of abdomen with longitudinal rows of darkened tubercular spots, three on each side of the median, the spots of the two rows, along the median are oval and usually bear two setæ, arising from conspicuous tubercles, while the spots of the remaining four rows are circular and but one setæ arises from each. Cornicles concolorous and tubercular.

Measurements.—(From specimens in alcohol and balsam, taken on Trifolium pratense at Urbana, Ill., November 15 and 26, 1907.) Length of body, 1.636–2.072, average, 1.848 mm.; width, 0.737–0.992, average, 0.864 mm.; antenna, I, 0.070; II, 0.060; III, 0.358–0.473, average, 0.407; IV, 0.179–0.236, average, 0.199; V, 0.179–0.228, average, 0.207; VI, basal, 0.122–0.146, average, 0.133; VI, filament, 0.138–0.147, average, 0.142; total (average), 1.218 mm.; cornicles, 0.061 mm.; hind tarsus, 0.134 mm.

Egg.—The egg is elliptical, of a bright orange color when first laid, and measures 0.578 mm. in length by 0.252 mm. in width. The average number of eggs found in the abdomens of a number of specimens examined was 10.

Winged male.—Head and thorax light olive green, abdomen pale yellow green with conspicuous black markings. Antennæ black, excepting two basal segments, as long as body, and with circular sensoria on segments III, IV and V, as follows: 12–15 in a row on III, 2–4 on IV, and 3–5 on V. (Pl. XXIII, fig. 31.) Eyes black. Beak black at tip and not reaching to coxæ of middle pair of legs. Wings hyaline, with dark wing veins slightly margined with brown, and a very small brownish patch at end of each vein; stigmal vein obsolescent; the terminal fork of the discoidal branching at about one half the distance from the margin to where the discoidal first branches. Abdomen with a longitudinal row of large, black, oval spots on each side of the dorsal median line, and each spot bearing one or two very fine setæ; also there is a similar row of smaller setiferous spots on each side, and between these markings and those on the dorsal median are a few scattered and irregularly placed spots. Cornicles tubercular and dusky. Style globular, dusky, and edged with black.

Measurements.—(From four males; two in balsam taken on Trifolium pratense, November 15, 1907, and the others reared in the insectary February 1, 1908, and measured immediately after mounting in balsam.) Length of body, 1.091 (body somewhat shrunken)—1.382, average, 1.261 mm.; width, 0.509–0.582, average, 0.536 mm.; expanse of wings, 4.1571 mm.; length of wings, 1.827 mm.; antenna, I, 0.068; II, 0.054; III, 0.472–0.554, average, 0.513; IV, 0.277–0.358; average, 0.309; V, 0.261–0.318, average, 0.292; VI, basal, 0.138–0.163, average, 0.153; VI, filament, 0.146–0.163, average, 0.156; total, 1.545 mm.; cornicles, 0.049 mm.; hind tarsus, 0.130 mm.

The Red-clover Aphis (**Aphis bakeri** Cowen).

While examining the base of a red-clover plant (Trifolium pratense) August 5, 1907, at Urbana, Ill., I noticed a colony of immature pinkish aphids, which were apparently being attended by the large black ant (Formica fusca L.) The aphids were upon the undersides of the stems close to the ground, and the ants had built a roof-like structure, composed of debris, over the stems, evidently for the protection of the aphids. The young aphids above mentioned were reared to adults and successive generations obtained. In the fall, an infested clover plant was placed in the cold insectary room—this having approximately the out-of-door temperature—where it remained until the middle of January, 1908. When examined at this date only pupæ were found, and these, when brought into a warm room, became winged and produced young. I have also found this species at Leroy, Ill., September 9, on T. pratense, and situated on the plant as were those found at Urbana, but they were attended by another species of ant (Cremastogaster lineolata Say). During 1908 I have found this species very common in fields and along roadways, on T. pratense and attended by several species of ants, namely, Lasius niger var. americanus, and the two species mentioned above. Here the aphids commonly infested the upper parts of the stems and the flowers, as well as the stems near the base.

Several generations were carried through in the insectary, and the following life-history notes taken: The number of young produced by an individual female was found to vary from 61 to 72, giving an average of 2 to 3 young per day, the largest number of young produced by a single female in one day being 7. Usually the female lives 6 or 8 days after the birth of the last young.

Because of the pinkish color of the immature individuals and the pseudo-subterranean habit, I determined the species tentatively as Aphis trifolii of Oestlund, which, in the original descriptions was characterized as a subterranean species found on Trifolium repens L., and with a pinkish color, no other definite characteristics being given. I sent specimens to Prof. O. W. Oestlund who examined them and wrote to me that he believed them to be the same species described by him some twenty years ago, and named Aphis trifolii; though he had never seen the adult form before, either spuriæ or migrants, and his original description was based only on the larvæ.

Later, having received specimens of Aphis bakeri Cowen from Prof. C. P. Gillette, I noticed the similarity between these and my

clover aphis. I accordingly sent Professor Gillette specimens, in regard to which he reported that they "seem to be identical with what we have been calling Aphis bakeri. A. bakeri is not a subterranean species, but it does work close about the bases of the plants, particularly during the colder portions of the year." He also stated that A. cephalicola Cow. was now considered a synonym of A. bakeri, and further that he had collected it on apple and Cratægus as well as on clover.

Last summer (1907) I received specimens of a clover aphis from Mr. Paul Hayhurst, which I determined as A. cephalicola, not knowing at the time that it was a synonym of A. bakeri. These specimens were collected in Minnesota and Mr. Hayhurst has written that he has also taken this species in Kansas and the District of Columbia.

I have used the name of A. bakeri as having priority, inasmuch as the incomplete description of A. trifolii was made from immature individuals only, and we can not be certain that this is the same species; although the pinkish coloration of some of the immature individuals, as well as pseudo-subterranean habit, suggests that they are what was described as A. trifolii.

DESCRIPTIONS.

Winged viviparous female.—General color black. Head jet black. (Pl. III, fig. 23.) Antennæ black, not reaching the cornicles, and with numerous unequal tuberculate sensoria, irregularly placed on segments III, IV, and V, as follows: 22–33 on III, 2–18 on IV and 1–11 on V (usually, however, but the one large distal sensorium on V), also several smaller ones at the distal end of the thickened base of VI; segment III usually the longest, but occasionally it is subequal to VI (=VI and VII of some authors), IV slightly shorter than the filament of VI, V about half the length of III, and the basal portion of VI about half the length of IV. (Pl. XXIII, fig. 24.) Eyes black. Beak not reaching beyond the coxæ of the middle pair of legs. Thorax jet black. Wings hyaline and with dark veins; the first and second discoidal usually branching at one half the distance from the margin to the third discoidal, this, however, is more or less variable, the distance sometimes being greater, and sometimes less, than one half. (Pl. XXIII, fig. 22.) Legs almost entirely black. Abdomen more or less glossy and appearing black to the naked eye. Magnification shows a large, black patch covering most of the dorsum, and two rows of small black spots along the margin, one on each side; the remainder of the dorsum having a greenish tint. The black patch is solid, except one bar anteriorly, and several posteriorly, to it. (Sometimes the dorsal patch, instead of being almost an entire mass, is made up entirely of individual transverse bars.) Cornicles black, imbricated, and more or less flaring at the apex. (Pl. XXIII, fig. 26.) Style black, and conical. (Pl. XXIII, fig. 27.)

Measurements.—(Many specimens were measured, and the maximum and minimum, as well as the averages, are given. There is considerable variation in the actual measurements of the antennal segments, length of body, etc., between different individuals, but the relative lengths of the antennal segments, length of body, etc., are quite constant.) Length of body, 1.2726–1.8543, average, 1.4857 mm.; width, 0.6181–0.7979, average, 0.6825 mm.; length of wing, (average) 2.39 mm.; width, 0.88 mm.; antenna, I, 0.0682; II, 0.0565; III,

0.2934–0.4564, average, 0.3328; IV, 0.1548–0.2934, average, 0.1913; V, 0.1222–0.2282, average, 0.1462; VI, basal, 0.0815–0.1141, average, 0.0986; VI, filament, 0.2119–0.3423, average 0.2494; total (average), 1.1430 mm.; cornicles, 0.1032 mm.; style, 0.0788 mm.; hind tarsus, 0.1059. mm.

Pupa.—Head and thorax with a pinkish tint, and somewhat mottled, or pale green. Eyes black. Tip of beak black. Antennæ pale, excepting the last segment, which is dusky. Wing-pads pale with a greenish yellow tint. Legs pale. Abdomen dirty greenish, and sometimes with a yellowish or pinkish tint. Cornicles and style pale.

Wingless viviparous female.—The general body color, when examined with the naked eye, varying from dirty green or yellowish green to almost jet black. Head and portion of the thorax pale to dark dirty green. Antennæ about one half the body in length; the two basal segments dusky, the third pale, and the remaining segments darkening to black. (Pl. XXIII, fig. 25.) Eyes black. Legs, except the articulations and the tarsi, concolorous with the body coloration. Abdomen and posterior portion of the thorax dark dirty green to black green, and covered with many fine dark spots, which are scattered more or less irregularly over the dorsum. Around the cornicles is a semicircular immaculate area, and upon each of the last four abdominal segments is a more or less distinct transverse black band. Ventral surface of the abdomen immaculate, excepting a black blotch at the extreme posterior end. Cornicles pale, imbricate, and slightly flaring at the tips; subequal to the tarsus in length. The dorsally curved style pale, and with a dark margin, conical, and slightly less than the cornicles in length.

Measurements.—Length of body, 1.927–2.218, average, 2.127 mm.: width, 1.136–1.164, average, 1.146 mm.; antenna, I, 0.0621; II, 0.0516; III, 0.2282–0.3097, average, 0.2681; IV, 0.1304–0.2119, average, 0.1850; V, 0.1059–0.1630, average, 0.1418; VI, basal, 0.0733–0.0978, average, 0.0912; VI, filament, 0.1793–0.2526, average, 0.2192; total (average), 1.019 mm.; cornicles, 0.1263 mm.; style, 0.1121 mm.; hind tarsus, 0.1141 mm.

Sexual forms—The sexual generation has never been obtained, and from the data above it is evident that this species can hibernate in this latitude as viviparous individuals. Its alternate food plant, the apple, may possibly be the host upon which the sexual forms are produced, though Aphis bakeri has not as yet been found on apple in Illinois.

EXPLANATION OF PLATES.

Myzus elæagni Del G.—Plate XXI, figs. 1–9.

Figure 1, fore wing; 2, antenna of winged ♂; 3, of winged viviparous ♀; 4, of wingless oviparous ♀; 5, of wingless viviparous ♀; 6, head of winged viviparous ♀; 7, style of wingless viviparous ♀; 8, cornicle of winged viviparous ♀; 9, hind tibia of wingless oviparous ♀.

Rhopalosiphum berberidis Kalt.—Plate XXI, figs. 10–11; Plate XXII, figs. 12–18.

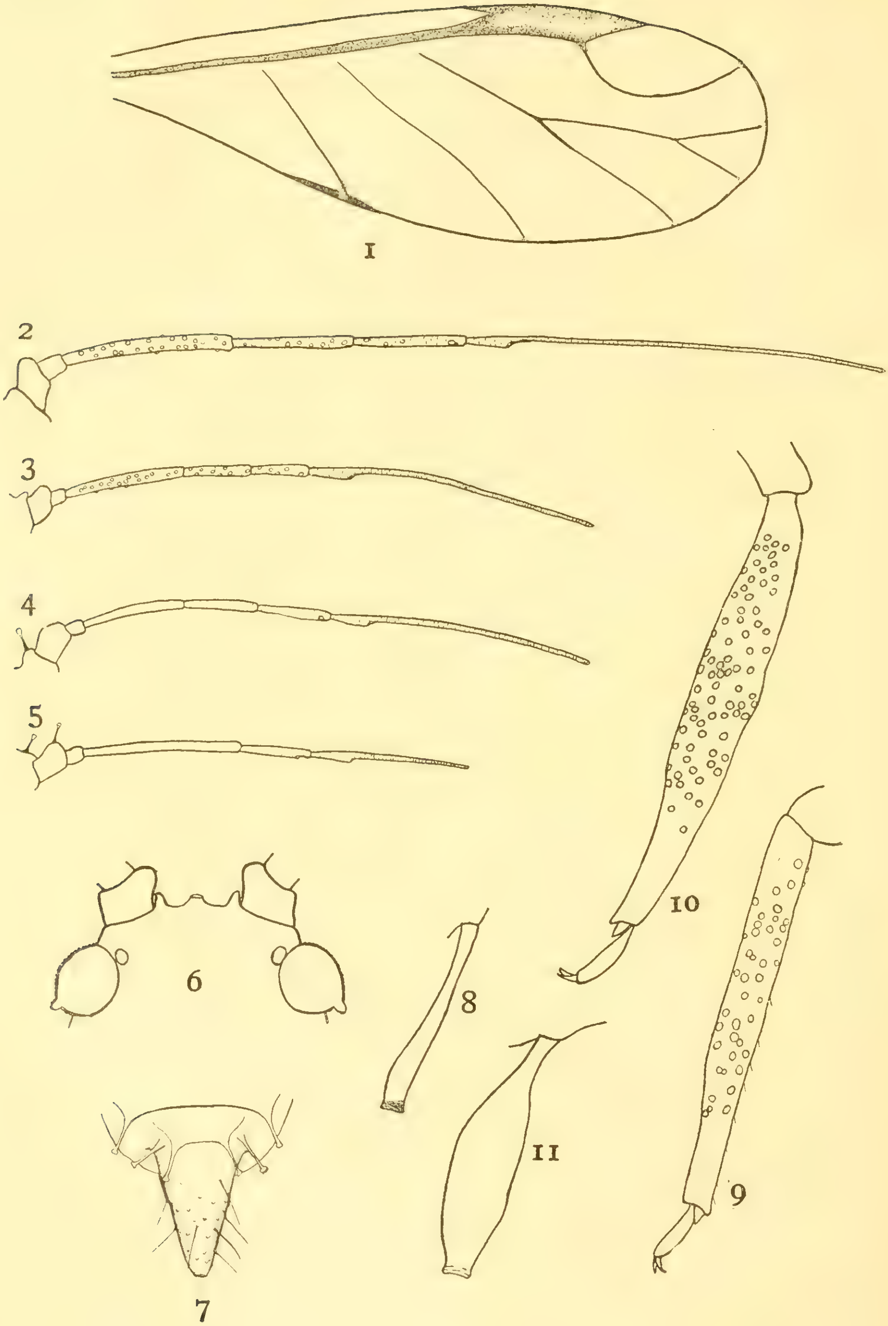
Figure 10, hind tibia of wingless oviparous ♀; 11, cornicle of wingless vivivarous ♀; 12, fore wing; 13, style; 14, antenna of winged ♂; 15, of winged viviparous ♀; 16, of wingless oviparous ♀; 17, of wingless viviparous ♀; 18, head of winged viviparous ♀.

Callipterus trifolii Mon.—Plate XXII, figs. 19–21; Plate XXIII, 28–33.

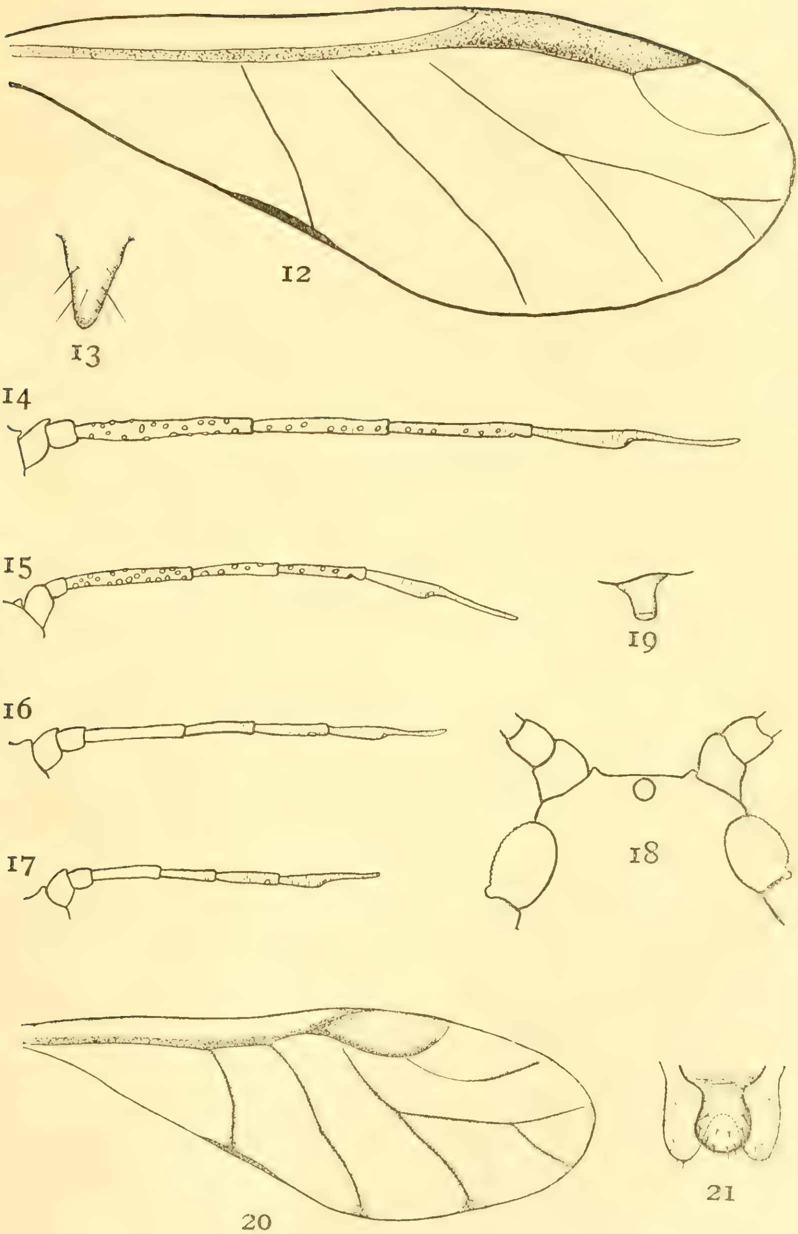
Figure 19, cornicle of winged viviparous ♀; 20, fore wing; 21, style of winged viviparous ♀; 28, head of winged viviparous ♀; 29, antenna of winged viviparous ♀; 30, of wingless viviparous ♀; 31, of winged ♂; 32, of wingless oviparous ♀; 33, hind tibia of wingless oviparous ♀.

Aphis bakeri Cowen.—Plate XXIII, figs. 22–27.

Figure 22, fore wing; 23, head of winged viviparous ♀; 24, antenna of winged viviparous ♀; 25, of wingless viviparous ♀; 26, cornicle of winged viviparous ♀; 27, style of winged viviparous ♀.



J. J. Davis.



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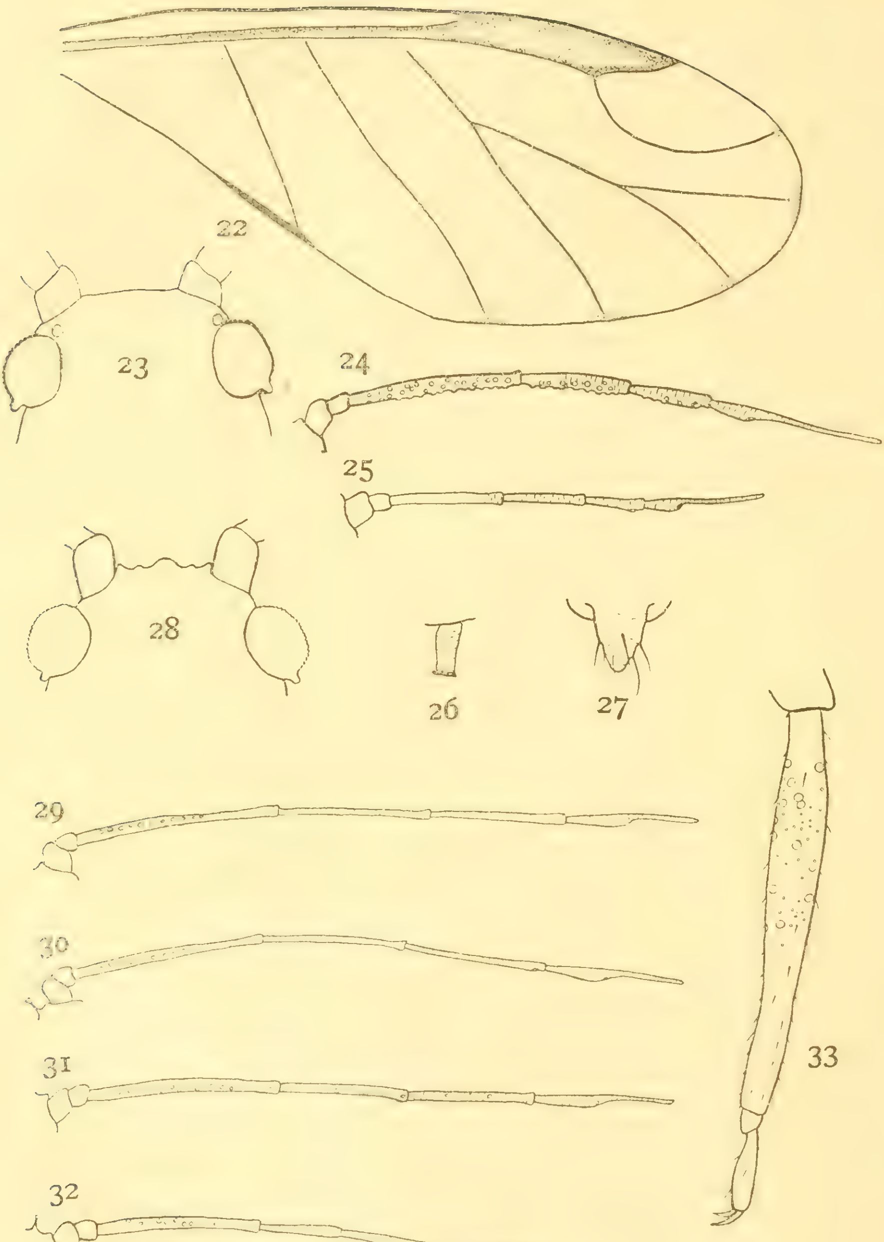

J. J. Davis.

MUSCLE ATTACHMENT IN INSECTS.*

William A. Riley.

As a rule, writers on insect histology have been content to state that the muscles are attached to the body-wall, without attempting to explain the mode of attachment. Within the past few years considerable attention has been paid to this phase of the subject, but there is little agreement in the views expressed and the question can by no means be regarded as closed. For some time, in connection with general work, the writer has paid special attention to this question, intending to make a study of the conditions in a wide series of insects. The comprehensive work of Snethlage, '05, and his exhaustive review of the literature, have rendered superfluous extended publication of these results but it is desired to call attention here to some features of the subject which have not been emphasized, and especially to the striking conditions to be found in the nymphs of Anax, a dragon-fly.

Theoretically, considering the structure of the body-wall of an arthropod, the muscles may be attached in any one of the several different ways. The fibers may be fastened directly to the cuticula or they may be attached through the intermediary of the hypodermal cells.

In the first instance, either the muscle fibers would force their way between the hypodermal cells in order to reach the cuticula (text-figure *A*), or their fibrils would pass directly through the hypodermal cell-body, (text-figure *B*).

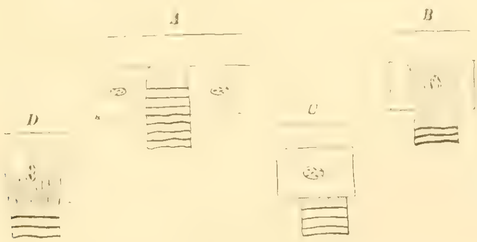

Fig. 6. Diagrams showing four possible methods of attachment of muscle fibers in arthropods. For explanation see text.

In case the attachment be through the intermediary of the hypodermal cells, the fibers might abut against the basement

*Contribution from the Entomological Laboratory of Cornell University.

membrane, being soldered to the cell, as in *C*, of the text-figure. Or, as in *D*, the union might be due to the interlacing or dovetailing of the muscle fibrils with those of the hypodermal cells.

Apparently clear illustrations of the direct passage of the muscle fibrils through the hypodermis are afforded by sections of the nymph of Chortophaga viridifasciata, an Acridid. Such a section is represented in the photomicrograph, plate XXIV, fig. 1, and from the study of such sections alone there would be little question that the muscle fibrils are attached directly to the cuticula. Unless they have themselves become fibrilloid there is left at the point of muscle attachment but little trace of the hypodermal cells. They are clearly indicated by their nuclei, which are larger than those of the muscle and in which the distribution of the chromatin is also different. Moreover, their limits are shown by the very definite, dark-brown pigment granules similar to those found in the hypodermal cells of other regions.

Snethlage has pointed out that it is easy to see how an oblique section through the muscle and the overlying hypodermis would present, in some cases, the appearance shown in *C*, and thus lead to a misinterpretation. On the other hand, if an axial section presents the appearance shown in the photograph, it becomes a question of determining whether the prominent fibrils in the hypodermal cells are muscle fibrils, pushing through the cell as in *B*, or whether they are what Maziarski, '03, has aptly denominated tonomitomes, i. e., filaments of protoplasm differentiated in the epithelial cell itself, as a result of mechanical stimulus.

It was when examining some sections of the nymph of Anax, prepared by Dr. Needham for the study of wing development, that I had my attention attracted to striking evidence in favor of the view that muscle attachment in insects is through the intermediary of the hypodermal cells, as has been maintained by Weismann, '63, Leydig, '85, Bertkau, '85, Duboscq, '98, and others.

As may be seen from figure 2, the hypodermal cells in the region of the muscle attachment are very elongate and narrow, measuring about 50μ in length and 5μ in width. They are sharply differentiated by the haematoxylin-eosin stain, being much bluer than the attached muscles. Their nuclei are also distinct from those of the muscle fibers. The cells are feebly

longitudinally striate but their fibrils appear finer than those of the muscle and there is no clear evidence of direct continuity of the two. On the contrary, I believe that there occurs a splicing or fusion of the two types of fibrils, the basement membrane being lacking at the point of contact.

The sections first studied were of alcoholic material, cut at 10μ and stained in haematoxylin and eosin. In order to make a more careful study material was fixed in Flemming's and in Gilson's fluids, sectioned at 2-3μ and stained in iron haematoxylin. The appearance was then very similar to that presented by the above mentioned sections of Chortophaga.

As may be seen from figure 3, the striae are much more prominent and the muscle fibrils, as in Chortophaga, are apparently continued through the body of the hypodermal cells to attach directly to the cuticula. This appearance is greatly emphasized in the sections in which, as in figure 4, the cuticular layer has been torn away. Then the distal ends of the cells present a frayed-out appearance, due to the projecting fibrils.

At the Chicago meeting of the American Association I exhibited lantern slides from these preparations and, emphasizing as they do, the appearances found by Snethlage in a large series of insects, I believed that they represented direct attachment of the muscle fibers to the cuticula. Studies of developing muscle in the postembryonic stages, and renewed examinations of the conditions in Anax and other forms have forced me to return to my first interpretation of the conditions.

Most instructive were sections through the developing wing-muscles of Anax such as represented by figures 5 and 6. In these photographs there is to be seen an apodeme-like invagination of the body-wall, surrounded by its hypodermal cells. Near its apex these cells become suddenly greatly elongated, their nuclei become fusiform, and placed at the bases of the cells, while prominent longitudinal striae appear within them. The basement membrane is deflected to enclose the muscle fibers and, in fact, the whole appearance seems to support Snethlage's contention that the muscle fibers are hypodermal in origin, merely prolongations of the epithelial cells.

From my studies I am, however, unable to accept this view that the muscle fibers of the arthropods are structurally prolongations of the chitinogenous cells. Snethlage bases his theory on a study of the development of the musculature of the nauplii of

Artemia salina, but I do not believe that even for this species his evidence is conclusive, and I do not find any satisfactory evidence to overthrow the almost unanimous testimony of careful workers in favor of the mesodermal origin of this tissue in insects. Snethlage objects that the concept of the inpushing of a special, independently originating tissue at definite points in the body-wall savors of the theory of "praestabilierten Harmonie" but this objection would no more hold than in the case of nerve endings, or others that might be cited. Moreover, he overlooks the fact that however the muscle *originated*, his own objection would still hold when its *insertion* is considered.

An important point to be considered in a study of the method of muscle attachment is the remarkable differentiation of the hypodermal cells in the region of the attachment. In many cases as in Anax, they become very greatly elongate and fibrilloid, as compared with the immediately neighboring cells of the body-wall. This is especially clearly seen in figure 5. If the muscles are attached directly to the cuticula, why should there be this great elongation of the epithelium? If, on the other hand, the attachment is through the intermediary of the hypodermal cells, it is just such a change which we might expect.

Van Rees, '89, found that in the thorax of the pupa of Musca the muscle tendons are developed in this manner, as prolongations of the hypodermal cells which grow inward to meet the developing muscle. Similar studies by Berlese, '01, and by Silvestri, '03, lead them to declare emphatically in favor of the view that the attachment of the muscle is through the intermediary of the hypodermal cells.

Hecht, '99, has called attention to the remarkable appearance of the muscular insertions in the myrmicophilous dipterous larva, Microdon. In this form the fibrillated appearance can be traced not only through the hypodermal cells but through the total thickness of the greatly developed secondary cuticula, spreading out fan-like under the primary cuticula. Through the kindness of E. L. Jenne, I have had the opportunity of examining a number of sections of these larvae and find the fibrils very prominently developed but by no means as clearly muscular as Hecht's figures would indicate. A very similar condition is to be found in sections of Muscid larvae, though in the ones which I studied the arrangement of the fibrils was in the form of a cone with its base entad, rather than as in Microdon. In none of the cases were the

conditions such as to preclude the purely hypodermal origin of these fibrils.

A number of writers, notably Tower, '06, have called attention to the fact that when the cuticula loosens, its attachment persists longer at the point of attachment of the muscles than elsewhere and they have thought to see in this proof of the view that the muscles were attached directly to the cuticula. Such evidence is by no means conclusive for as in the instances mentioned above, this condition might very well prevail in either case.

The whole problem is one of great interest and, as stated at the outset, can be by no means regarded as closed. I cannot believe with Sinety that we have the anomaly of both methods occurring within different species of even the same family of insects. The evidence very strongly supports Maziarski's view that the so-called muscular fibrils passing through the hypodermal cells are in reality modifications of its own protoplasm,—true tonomitomes.

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EXPLANATION OF PLATE XXIV.

Fig. 1. Muscle attachment in the nymph of Chortophaga viridifasciata, an Acridid.

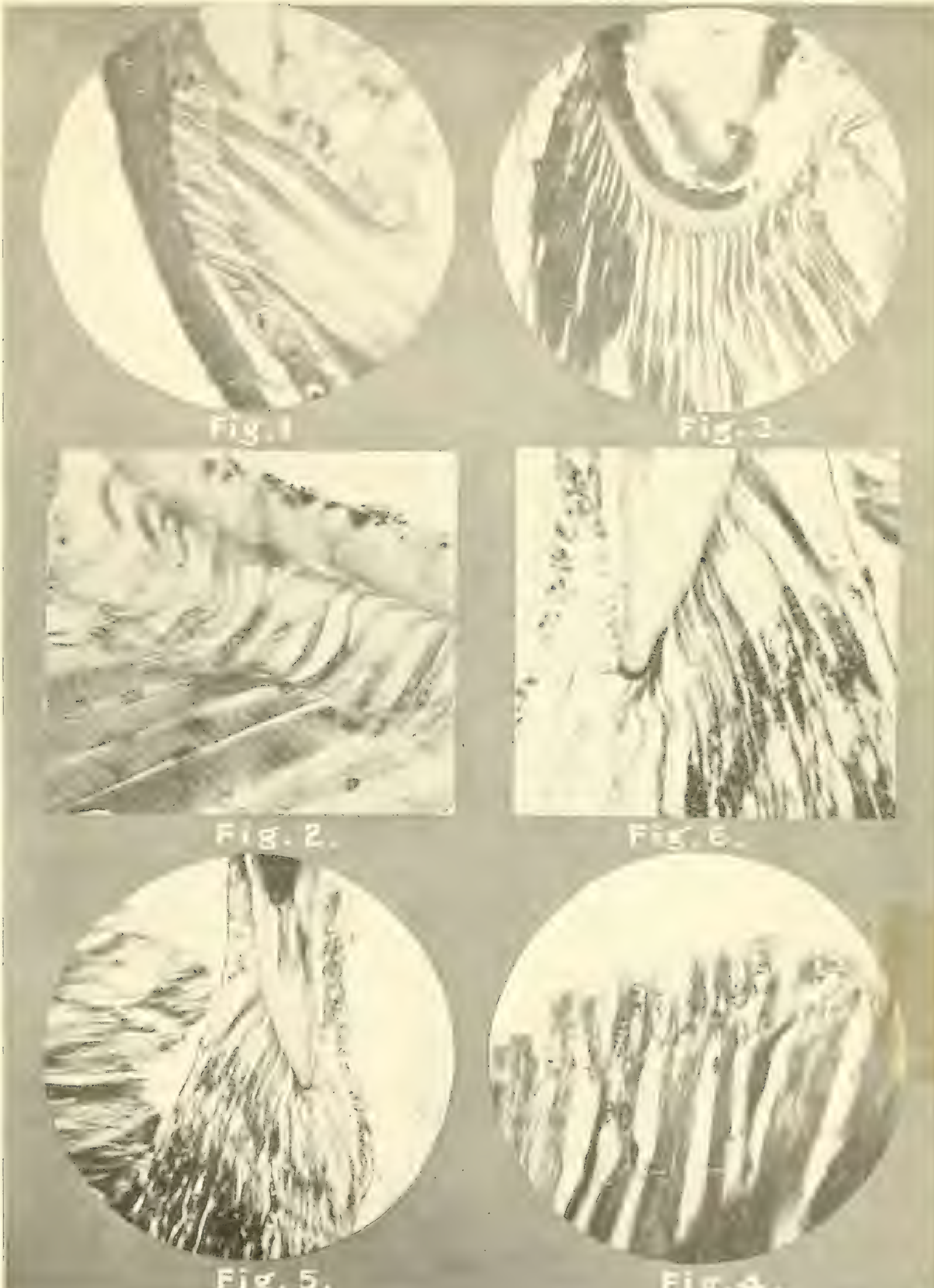
Fig. 2. A portion of the body-wall of a nymph of Anax, showing the greatly elongated hypodermal cells at the point of attachment of the muscles.

Fig. 3. Muscle attachment in another individual of Anax.

Fig. 4. A preparation of Anax from which the cuticula has been broken away, showing the frayed-out ends of the hypodermal cells.

Fig. 5. An apodeme of a nymph of Anax, showing the greatly elongated hypodermal cells at the point of attachment of the developing muscle.

Fig. 6. The same, enlarged



W. A. Riley.

CRITICAL NOTES ON THE CLASSIFICATION OF THE CORDULIINAE (Odonata).

By James G. Needham.

Ten years ago I studied such of the dragonflies of the subfamily Corduliinae as I found accessible in this country. I made exchanges, and visited the principal museums, and was able to get acquainted with about three fourths of the known genera. I studied them especially with reference to their wings, and drew up a sketch of the principal lines of their specialization as evidenced by the wing veins. This mere outline was later included in my "Genealogic Study of Dragonfly Wing Venation".[1] There remained a number of genera of which I had no knowledge, save such as might be gained from brief descriptions, that noticed but few venational characters, and these often the least important ones. Even at so recent a date, there were no good figures of dragonfly venation published, save only a few of fossil species; and the cuts illustrating dragonfly venation in the text books were for the most part the worst of caricatures, as in some of them they still continue to be.[2]

In my first Adirondack report,[3] I attempted to arrange the North American Genera in natural order, basing the system therein used chiefly on wing venation and on nymphal characters. When characters so diverse in kind give concurrent evidence of relationships, one can arrange a group with reasonable assurance. But in my characterization of groups in that report I used beside the more fundamental characters sometimes more trivial ones, applicable only to North American genera, my object being merely to facilitate the recognition of the different members of our local fauna.

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1. Proc. U. S. Nat. Mus. Vol. 26, pp. 739–741, 1903.

2. Witness the dragonfly venation figure in Kellogg's American Insects (fig. 121, p. 89.) This is just a little better than that of stonefly venation (fig. 109) on page 73. These figures are not to be regarded bad because they are crude diagrams, but because they are false and misleading. In the diagram, for example, of the dragonfly wing (fig. 121), the arculus, the vein labelled 7 at its base and the anal veins are all shown in relations with other parts that they never bear to these parts in any living dragonfly. This is a copied figure, to be sure, and the original figures of American Insects are not subject to this criticism.

3. Bull. 47, N. Y. State Museum.

Hence, although I was able, through the tracing of lines of specialization, to indicate natural groups, I made no attempt to locate all the genera of the world in these groups, nor to set their precise boundaries.

The recent magnificent work of Monsieur R. Martin on the Corduliinae of the great de Selys collection[4] supplies excellent figures of the venation of every known genus (as well as figures of the genitalia of most of the species) and is a boon to every worker on the Odonata. Naturally, the system of classification used in this work is largely that of de Selys: but M. Martin has furnished in his illustrations and in his key abundant data for a more modern arrangement of the group. As I have had opportunity, I have been studying this data from time to time, comparing the figures with my own photographs, and drawing up a key to the genera of the world as a means of setting forth a more natural arrangement of the entire group.

I had these keys before me when Mr. Williamson's recent "Revision of the Classification[5] of the Corduliinae" came to hand, and I have studied this paper with great interest and pleasure. Williamson's arrangement of the genera is a vast improvement over the pioneer arrangement of de Selys; and the improvement grows out of better discernment as to what are the fundamental venational characters. De Selys' primary division of the group, (made, it must not be forgotten, at a time when these characters were little understood), was based upon the presence or absence of crossveins in the supertriangle. These crossveins are always weak and functionally unimportant, and if sometimes fairly constant, this is just the sort of character most likely to prove misleading at critical points. It was only by too close adherence to this criterion that Aeschnosoma, for example, could be severed from its obvious allies, Somatochlora, etc., and immolated among the coarse Macromians. Williamson abandons the use of such characters (perhaps a little too completely), and wisely bases his arrangement on the disposition of the principal veins of the wing. He arranges the genera in five groups "of approximately co-ordinate rank", and demonstrates that the members of each group possess numerous marks of affinity. But he leaves three genera *incertae sedis* (the three Corduline genera with triangles of the

4. Collections Zoologiques du Baron Edm. de Selys Longchamps; Cataloge Systematique et Descriptif. Fascicle XVII. Brussels, 1906.

5. Entom. News. Vol. 19, pp. 428–431, 1908.

fore wings four sided) out in the cold, and, quite apart from the theoretical improbability of more than two co-ordinate groups in any evolutionary series, I think he has not discriminated sufficiently as to the value of the different characters to be found in the disposition of principal veins.

Hence it will not be amiss to present in this paper some further studies on the venation of the group and their bearings on the classification.

What are the fundamental venational characters in the Corduliinae? Undoubtedly they are those connected with the differentiation between fore and hind wings. For fore and hind wing were originally alike. In each of the larger subfamilies of Odonata may be found one or more weak and dimunitive forms that have fore and hind wings much alike still. I copy Martin's figure

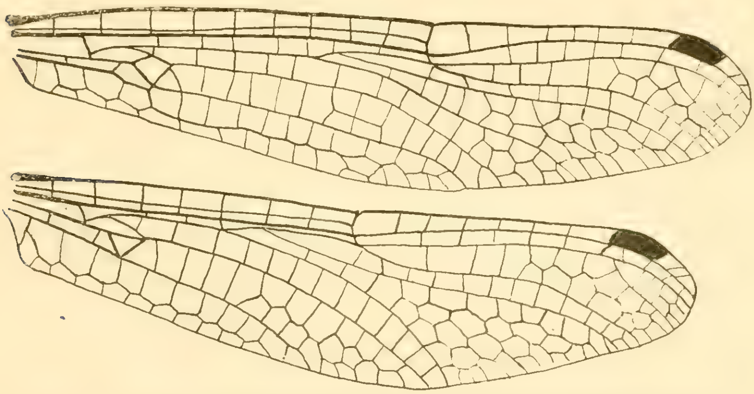

Fig. 7. The wings of Cordulephya pygmaea Selys (after Martin).

of the little Australian species, Cordulephya pygmaea Selys, in illustration of this for the Corduliinae. Here the two wings correspond with remarkable closeness, and may be compared through out, almost cell for cell. And, as were befitting in a form so generalized, the "triangle" of the forewing has not become triangular. Elsewhere[6] I have shown how the triangle is formed by the approximation of the anterior ends of two crossveins upon a neighboring vein. This process is complete in the hind wing of Cordulephya.

6. Amer. Nat. Vol. 32. pp. 903–911, 1898, and Proc. U. S. Nat. Mus., Vol. 26, p. 717, 1903.

Obviously differences in the approximation of these cross-veins are differences of degree only. Such differences are not fundamental enough for primary divisions of a subfamily. It would be hard to find three genera with less affinity than the three having four sided triangles in this subfamily. Williamson has indicated some diametrically opposite developments in Neophya and Cordulephya, and I have shown[7] that the four sided triangle of Pentathemis is not primitive, but secondarily derived from a three-sided one, and is an extreme case of specialization.

With the exception of Cordulephya, all Corduline genera have fore and hind wings of very different form. This differentiation has been brought about by a number of minor shifts of parts, which I have pointed out in the paper last cited, and *chiefly* by the broadening of the hind angle of the hind wing and the development of an anal loop for its support. This development has followed two distinct methods:

I. An anal loop of compact Cordulegasterine form (fig. 8, *d*, *l*), externally delimited by a stout straight basal segment of the vein Cu2, has interposed itself squarely between the triangle and the hind angle; and in consequence there is slight tendency for the triangle to recede to the level of the arculus. This is the group MACROMIINAE, which I characterized in 1903. It is Williamson's group V with Macromidia added. It ought to be recognizable by the characters I stated even though its constituent genera were not all named. In my judgment it is co-ordinate with all the other Corduliinae s. str. put together. If any one think it insufficiently defined, let him distinguish between the long recognized Libellulinae and Corduliinae s. str. with equal definiteness.

II. Anal loop tending from the first to be elongate and narrow and to extend itself outward along the cubital vein, with concurrent recession of the triangle to the level of the arculus (fig. 8, *a*). This is the group CORDULIINAE s. str.

These tendencies are least marked in the aberrant genera Gomphomacromia (fig. 8, *b*) and Idyonyx, in which the anal loop has remained short but even in these the form of the anal loop and its relations to the basal portion of vein Cu2, are distinct from the Macromian type: In Idionyx and in all except Gomphomacromia the bisector of the loop, dividing its two parallel rows of cells

7. Proc. U. S. Nat. Mus. Vol. 26, p. 718, footnote.

longitudinally, is established; there is nothing like a bisector in the Macromian line.

The anal loop, although just beginning to be recognized and used in the systematic study of the Odonata, has undoubtedly played a role of first importance in the evolution of the wings of the Corduliinae. Within the restricted group just defined the tip of the anal loop has developed in two divergent ways:

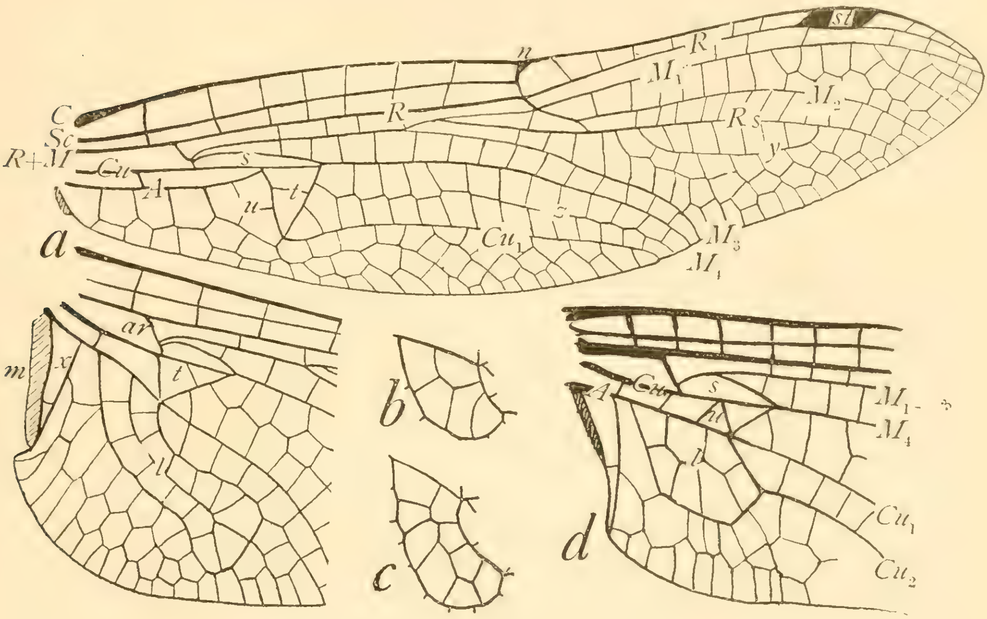

Fig. 8. Typical structures of Corduline wings: (a) the wings of Tetragoneuria cynosura Say; (b) the anal loop of Gomphomacromia paradoxa; (C) the same of Syncordulia gracilis; (d) base of hind wing of Macromia. Veins: (c), costa; (Sc) subcosta; (R) radius; (M) media; (Cu) cubitus; (A) anal; (Rs) radial sector; other branches numbered from front to rear. Other parts, (ar) arculus; (n) nodus; (st) stigma; (s) supertriangle; (t) triangle; (u) subtriangle; (m) membranule; (x) anal triangle of the male; (l) anal loop; (y) radial supplement; (z) median supplement.

(1) It has extended itself outward parallel to the vein Cu1 in a bilaterally symmetrical point, and the tendency of the triangle to be concurrently retracted to the level of the arculus has been least where the elongating loop has most closely paralleled vein Cu1. (Idomacromia, etc.) This tendency may be said to characterize in a general way Williamson's groups III and IV, with Neophya added to group IV. The Triangle has reached the level

of the arculus only in Neophya and certain species of Neocordulia, and in the latter, the anal loop is truncated on the tip and shows a very slight apical widening.

(2) On the other hand, the anal loop tends elsewhere to become unsymmetrical on its broadly truncated apical end, and to develop a long posterior angle toward the hind margin of the wing (fig. 8, *a*, *l*). This is the most salient characteristic of Williamson's groups I and II, with Pentathemis added to group II.

In endeavoring to trace the further cleavage of these groups, I have deemed these characters of most importance: (1) the primary differentiation between fore and hind wing; (2) the manner of development of an anal loop; (3) the form of the special braces formed at arculus, triangle and stigma, and (4) the mutual adjustments of the principal branches of veins in the outer field of the wing; and I have used such characters as the presence or absence of crossveins, only when characters like those above mentioned seemed to be wanting. I have largely copied Martin's arrangement of the genera of Williamson's group I. The minor divisions of the key need to be checked by the study of other characters. The venation of the Odonata is at the present time receiving more than its share of attention. There is great need of critical comparative study of other organs, and there is especial need of more knowledge of the immature stages.

KEY TO THE GENERA OF THE CORDULIINAE, s. lat., OF THE WORLD.

(Based on venational characters.)

a) Anal loop compact, little longer than broad, without bisector, delimited distally by a short straight basal segment of vein Cu2; triangle of the forewing transversely elongate, and that of the hind wing never retracted toward the arculus. SUB-FAMILY MACROMIINAE.

- b) Veins M3 and M4 straight or regularly arcuate behind the nodus.
  - c) Median (or basal) space traversed by crossveins; alternate antenodals often hypertrophied or thickened........... **Synthemis**
  - cc) Median space destitute of crossveins; anal loop considerably longer (in the axis of the wing) than broad....... **Macromidia**
- bb) Veins M3 and M4 distinctly undulate behind the nodus in both wings.
  - c) Triangles and subtriangles of the forewings traversed by crossveins.
    - d) Vein Cu where it bounds the subtriangle of the forewing on the proximal side strong and straight..................... **Azuma**
    - dd) Vein Cu where it bounds the subtriangle of the forewing, weak and angulate among the cells.................. **Epophthalmia**
  - cc) Triangles and subtriangles of the forewings free from crossveins.
    - d) Triangle of the forewings followed by two rows of cells. . **Macromia**
    - dd) Triangle of the forewings followed by a single row of cells..... **Phyllomacronia**

aa) Anal loop when present of elongate form bounded distally by a curving basal segment of vein Cu2, and traversed lengthwise by a more or less distinct bisector; two postanal cells in the forewing. SUB-FAMILY CORDULIINAE s. str.

b) With fore and hind wings closely similar; no anal loop. . . . **Cordulephya**

bb) Hind wings broader than the fore and with well developed anal loop.

c) Anal loop not widened at the distal end, nor with an unsymmetrical prolongation of the apex toward the hind margin. Triangle not retracted to the level of the arculus.*

d) Triangle of the forewing four sided; that of the hind wing retracted to the arculus, and the hind angle of the wing greatly expanded . . . . **Neophya**

dd) Triangle of the forewing normal; that of the hind wing not retracted to the arculus.

e) Anal vein extends almost or quite directly to the hind angle of the triangle in the forewing, and the subtriangle is elongate and four sided; veins M1–3 and M4 descend the arculus its enttire length, and are fused for an equal distance beyond it in both wings; post-nodal space (space between the nodus and the stigma) but half as long as the antenodal. . . . . **Idionyx**

ee) Anal vein reaches the triangle after being twice strongly deflected around the angles or the subtriangle; subtriangle three sided; postnodal space two thirds as long as the antenodal.

f) Veins M3 and M4 parallel at their distal ends: the bisector of the anal loop divides the basal part unequally, some of the cells on the side of it next the triangle being again divided.

g) With well developed median supplement in both fore and hind wing. . . . . **Idomacromia**

gg) With no median supplement developed in either wing **Nesocordulia**

ff) Veins M3 and M4 divergent to the outer wing margin anal loop consisting of but two rows of cells about equally divided by its bisector.

g) Anal loop short, and lacking a distinct bisector. . . . . **Gomphomacromia**

gg) Anal loop longer, and with distinct bisector.

h) Veins M3 and M4 of the forewing strongly divergent at tips; bisector of the anal loop (fig. 8, *c*) weak and angulate between the cells. . . . . **Syncordulia**

hh) Veins M3 and M4 of the forewing but slightly divergent at the wing margin: bisector of the anal loop better beveloped, usually but little angulated: stigma at least three times as long as wide.

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* Except in Neophya which is specialized so independently it will cause no confusion, and in one or two species of Neocordulia, which are truly synthetic forms, but in which the anal loop is rather more squarely truncated on the ends than in any of the others. N. volxemi Sel., in my opinion, agrees in all essential characters with typical Neocordulias, and ought not to be removed to Gomphomacromia, with which it does not at all agree in such important matters as the form and relations of the triangles the form of the anal loop, the conformation at the arculus, or the venation about the stigma.

The number of cell rows in a given wing area, like that beyond the triangle, when variable, is always determined merely by the presence or absence of weak crossveins.

Neophya is remarkable for the contrast between the two wings in point of specialization. The forewing has a triangle of the most primitive sort, while the hind wing exhibits the maximum of broadening of the hind angle together with complete retraction of the triangle to the arculus.

i) Veins M1–3 and M4 separate at their departure from the arculus in the forewing .... **Oxygastra**

ii) Veins M1–3 and M4 fused a little way beyond the arculus in the forewing .... **Neocordulia**

cc) Anal loop widened at its distal end and truncated more or less unsymmetrical, the hind angle being produced sensibly toward the adjacent wing margin. Triangle of the hind wing always retracted as far as the level of the arculus.

d) Veins M1–3 and M4 fused beyond their departure from the arculus; cells along the middle of the anal loop divided by the bisector very unequally, those lying on the cubital side being much narrower. Vein M3 distinctly undulate behind the nodus; median supplement distinctly developed in the fore wing; supertriangle with crossveins.

e) Veins M1–3 and M4 fused into a straight stalk at their departure from the arculus.......................... **Pentathemis**

ee) Veins M1–3 and M4 strongly arched forward at their departure from the arculus.

f) With more than 10 antenodal crossveins: superior appendages of the male forcipate...................... **Aeschnosoma**

ff) With 10 or fewer antenodal crossveins; appendages of the male not forcipate....................... **Libellulosoma**

dd) Veins M1–3 and M4 not fused in the forewing at their departure from the arculus: vein M3 straight or regularly arcuate behind the nodus. Supertriangle free from crossveins.

e) Veins M4 and Cu1 divergent to the wing margin.

f) Bisector of the anal loop furcate at the slightly unsymmetrical widening of distal end................... **Platycodulia**

ff) Bisector of the anal loop running into the posterior prolongation of the very unsymmetrically widened distal end .... **Neurocordulia**

ee) Veins M4 and Cu1 not divergent to the wing margin, usually slightly convergent.

f) Hind angle of hind wing rounded in the male: vein M4 more or less broken............................ **Hemicordulia**

ff) Hind wings angulate in the male.

g) 2nd cubito-anal crossvein present in the hind wing (therefore, the subtriangle present).

h) wings spotted.............................. **Epitheca**

hh) Wings clear............................. **Somatochlora**

gg) 2nd cubito-anal crossvein (and therefore also the subtriangle) absent in the hind wing.

h) Triangle of the forewing traversed by a crossvein.

i) Wings spotted with brown.

j) Triangle of the hind wing traversed by a crossvein, **Epicordulia**

jj) Triangle of the hind wing open.

k) Antenodals of the hind wing 6........ **Helocordulia**

kk) Antenodals of the hind wing 4 or 5. . **Tetragoneuria**

ii) Wings clear.

j) Antenodals about equal in number to the postnodals in the forewing .... **Cordulia**

jj) Antenodals decidedly more numerous than the postnodals in the forewing, **Procordulia and Paracordulia**

hh) Triangle of the forewing open .... **Dorocordulia**

A KEY TO THE SPECIES OF PROSPALTELLA, WITH TABLE OF HOSTS, AND DESCRIPTIONS OF FOUR NEW SPECIES.

By L. O. Howard.

The genus Prospalta, of the subfamily Aphelininae, was founded by the writer in 1894 (Insect Life, Vol. VII, p. 6) for P. murtfeldtii How., a parasite of Aspidiotus uvae and other Diaspine scales. Since that time other species have been described by Zehntner, Masi, Girault and the writer. Ashmead, noticing that the generic Prospalta was preoccupied in Lepidoptera (Walker, 1857,) proposed as a substitute the name Prospaltella in Proceedings Entomological Society of Washington, Vol. VI, p. 126, 1904. The descriptions are so widely separated in different publications that, for the sake of convenience in determination work, the following synoptical key has been drawn up. Masi, in Vol. III, of his important Contribuzioni all Conoscenza dei Calcididi Italiani (Portici, 1908), gives it as his opinion that P. tristis Zehnt., belongs rather to the genus Coccophagus; but the writer fortunately possesses cotypes of this species sent him by Doctor Zehntner, and is able to state that the species was correctly placed by its describer.

Genus **Prospaltella** Ashmead, 1904.

Prospalta Howard, 1894 (preoccupied).

1. Forewing with a trace of a very short pointed marginal vein, its lower margin curving strongly towards base of wing and then outwards to form outer border of stigmal.......................... **similis** Masi
   Forewing with upper margin of stigmal vein reaching wing margin at a point very slightly distad of its slightly reentering curve, thus faintly indicating a post marginal................................2
   Forewing without the slightest tendency towards a post marginal 3
2. Forewings nearly hyaline, sometimes very faintly dusky below marginal vein, occiput yellow..............................**koebelei** n. sp.
   Forewing with a very pronounced broad dark band below marginal vein, occiput with a broad transverse black band......**quercicola** n. sp.
3. Upper margin of stigmal vein reaching wing margin by a gradual proximal curve...4
   Marginal vein squarely truncate, stigmal proceeding from anal portion of truncation................................... **maculata** How.
   Marginal vein convexly truncate, upper margin of stigmal nearly parallel with wing margin...5
4. Flagellum of antennae distinctly clavate.............................6
   Flagellum nearly filiform 7
5. Wings nearly hyaline, only very faintly infuscated; legs uniformly pallid; antennae concolorous............................... **tristis** Zehnt.
   Wings with a pronounced infuscated patch below marginal vein; legs and antennae banded...9
   Wings nearly uniformly infuscated, legs banded, flagellum dark with slightly lighter tip to club ....**fuscipennis** Girault.

6. Wings with a broad dusky band below marginal vein; abdomen yellow with brown transverse band just caudad of middle........**citrella** n. sp.
   Wings hyaline..8
7. Joints 1 and 2 of funicle distinctly shorter than joint 3......**berlesei** How.
   Joints 1, 2 and 3 of funicle subequal in length...........**conjugatus** Masi.
8. Abdomen dusky, remainder of body yellow with occasional darker markings ....**aurantii** How.
   Head and thorax dark brown, nearly black; mesoscutellum lighter and abdomen with light patch in center above..............**brunnea** n. sp.
9. Hindwings with two rows of discal cilia..................**murtfeldtii** How.
   Disc of hindwings rather densely ciliate.............**fasciativentris** Girault.

New Species.

Prospaltella quercicola n. sp. ♀.

Female.—Length, 0.73 mm.; expanse, 1.53 mm.; greatest width of forewing, 0.26 mm.; antennae subfiliform; all funicle and club joints subequal in length and width; eyes very faintly hairy; forewing with the upper margin of stigmal vein reaching wing margin at a point very slightly distad of its slightly reentering curve, thus faintly indicating a postmarginal vein; abdomen and metanotum piceous; pronotum and front of mesoscutum, as well as propleura and mesopleura, also piceous; vertex of head bright lemon yellow; ocelli crimson; occiput black; all legs pallid except hind femora and trochanters, which are dark brown; antennae pallid yellow except terminal joint of club, which is fuscous; hind portion of mesoscutum, including all of the parapsides, lemon yellow; mesoscutellum nearly white; wings with a broad, well-defined dark fuscous band extending entirely across the wing from the submarginal and stigmal veins.

U. S. N. M. type No. 12163. Described from 14 female specimens reared by R. S. Woglum, of the Bureau of Entomology, U. S. Dept. Agric., April, 1908, from Aleyrodes gelatinosus Cock'll, on Oak, Los Angeles, Cal.

Prospaltella koebelei n. sp. ♀.

Female.—Length, 0.65 mm.; expanse, 1.65 mm.; greatest width of forewings, 0.26 mm.; antennae long, almost filiform; joint 1 of funicle slightly shorter than pedicel and only half as long as joint 2; joints 2 and 3 and basal joint of club subequal in length, the basal end of the club being slightly wider, joint 2 of club a little more than half as long as joint 1, terminal joint slightly longer; stigmal vein of forewing resembling that of the preceding species. Abdomen and pronotum brown; head entirely yellow; ocelli red; meso- and meta-notum dark yellow; legs pallid except hind femora, which are dusky; antennae yellow, pedicel and last two funicle joints darker than the rest; wings nearly hyaline, the disc of the forewing below marginal vein very faintly and indefinitely infuscated.

U. S. N. M. Type No. 12162. Described from 21 female specimens, reared by Albert Koebele, from Aspidiotus longispina Morg., Hawaii (Koebele's No. 1122).

Prospaltella citrella n. sp.

Female.—Length, 0.72 mm.; expanse 1.7 mm.; greatest width of forewing 0.245 mm. Antennae distinctly clavate, somewhat flattened; funicle joint 1 shorter than 2 and than 3; stigmal vein as with aurantii; forewings with a broad infuscate band extending from marginal vein to hinder border of wing. General color bright lemon-yellow; vertex deeper yellow, tending towards orange; eyes black; ocelli crimson; antennae yellow, terminal joint of club darker; all legs pallid; abdomen with a broad, transverse, brown band covering two segments caudad of middle.

Type No. 12164, U. S. N. M. Described from three female specimens reared by Dr. A. W. Morrill, Orlando, Fla., from Aleyrodes coronatus.

There is also in the collection of the Bureau of Entomology of the Department of Agriculture one specimen of what seems with little doubt to be this species, reared by Albert Koebele from males of a Kermes on Quercus undulata at Nogales, Ariz., May 3, 1897. On the same slide are several specimens of an Amitus (Proctotrypidae), and also several shriveled males of an Aphelinine which may possibly belong to the species above described, but their condition will not warrant a description.

Prospaltella brunnea, n. sp. ♀.

Female.—Length 0.85 mm.; expanse 1.7 mm.; greatest width of forewings 0.25 mm.; antennae distinctly clavate; first funicle joint subequal in length to joint 2 and to 3; wings hyaline; mesoscutum and scutellum with delicate hexagonal sculpturing. General color dark brown; mesoscutellum somewhat lighter; center of abdomen above occupied by a large white spot; antennae faintly yellowish; all legs pallid.

Type No. 12165, U. S. N. M. Described from one female specimen reared from Aleyrodes sp. (undescribed) on a climbing vine, collected at Bayamon, Porto Rico, January, 1899, by A. Busck. (Bureau of Entomology, No. 8423.)

Species Previously Described.

aurantii How.—♀—U. S., China, Australia, Europe.

Coccophagus aurantii Howard, Insect Life VI, 1894, p. 231.
Prospalta aurantii Howard, Insect Life, VII, 1894, p. 6.
Prospalta aurantii Howard, Revis. Aphelin. N. A., 1895, p. 41. fig. 13.

berlesei How.—♀—Eastern U. S., Italy.

Prospalta berlesei Howard, Entomological News, October, 1896, pp. 291–2, fig.
Prospalta berlesei Masi, Cont. Conoscenza Chalcididi Italiani III, pp. 143–5, figs. 40–43, (1908).

conjugata Masi—♀—Italy.

Prospalta conjugata Masi, Cont. Conoscenza Chalcididi Italiani III, pp. 146–8, figs. 44–46 (1908).

fasciativentris Girault.—♀—Ills.

Prospaltella fasciativentris Girault, Psyche, December, 1908.

fuscipennis Girault—♀—U. S.

Prospaltella fuscipennis Girault, Psyche, December, 1908.

maculata How.—♀—China, California.

Prospalta maculata Howard, New Genera and Species of Aphelininae, Tech. Ser. 12, Part IV, U. S. Dept. Agric., Bur. Entom., (1907), pp. 79–80, fig. 16.

murtfeldtii How.— ♀—U. S.

Prospalta murtfeldtii Howard, Insect Life, VII, 1894, p. 6.
Prospalta murtfeldtii Howard, Revis. Aphelininae N. A., 1895, p. 40, fig. 12.

similis Masi— ♀—Italy.

Prospalta similis Masi, Cont. Conoscenza Chalcididi Italiani, III, (1908), pp. 148–9, fig. 45.

tristis Zehnt.— ♀—Java.

Prospalta tristis Zehntner, Med. V. 2 Proefst. Oost-Java n. s. No. 29, 1896, pp. 11–12, figs. 17–21.

Table of Host Relations.

Parasites.	Hosts.
aurantii	Aonidiella aurantii citrinus (Coq.)
	Diaspidiotus ancylus (Putn.)
	Aspidiotus pini Comst.
	Lepidosaphes beckii (Newm.)
	Lepidosaphes concolor (Ckll.)
	Lepidosaphes eucalypti Crawford MS.
	Chionaspis sp.
	Aspidiotus hederae (Vall.)
	Diaspidiotus juglans-regiae (Comst.)
	Diaspidiotus howardi (Ckll.)
	Lepidosaphes gloverii (Pack.)
	Diaspidiotus forbesi (Johns.)
murtfeldti	Diaspidiotus uvae (Comst.)
tristis	Aleyrodes bergi Sign.
berlesei	Diaspis pentagona (Targ.)
maculata	Lepidosaphes beckii (Newm.)
conjugata	Aleyrodes brassicae Walk.
similis	Diaspidiotus ostreaeformis (Curt.)
quercicola	Aleyrodes gelatinosus Cook.
koebelei	Kermes sp. (males)
fuscipennis	Chrysomphalus obscurus (Comst.)
citrella	Aleyrodes coronatus (Quaintance)
brunnea	Aleyrodes sp. (on climbing vine)
fasciativentris	?Aspidiiotus perniciosus (Comst.)
	?Chionaspis furfura (Fitch.)
	Diaspidiotus forbesi (Johns.)
	Diaspidiotus aesculi (Johns.)
	Diaspidiotus juglans-regiae (Comst.)
	Aspidiotus sp. on Celtis.

TWO NEW SPECIES OF IDOLOTHRIPS.

By J. DOUGLAS HOOD, Urbana, Illinois.

Of the two species of Idolothrips to be described below, the former has been known to me for more than two years, but only recently have I recognized it as distinct from I. coniferarum Pergande, which was described in 1896. I regret that I have been unable directly to compare these species, but I have never met with the latter in the field, and have been unable to secure specimens from the original describer.

The value of the antennal sense cones in the definition of species seems to have been first recognized by Dr. Hinds, and in his descriptions, their form, size, and position are usually noted. In view of the value of these structures in specific, if not generic, determination, I have ventured to introduce into the following descriptions a method of recording their positions. The number of the antennal segment is followed, first by the number of sense cones on its inner surface, and then by the number on its outer surface; rudimentary cones are indicated by an exponent preceded by a plus sign. Thus 3, $2-1^{+1}$ means that on the inner surface of the third antennal segment are situated two fully-developed sense cones, while on the outer surface there is one fully developed and one rudimentary, cone.

Genus IDOLOTHRIPS Haliday, 1852.

Idolothrips armatus sp. nov. (fig. 9; 1, 2, and 3*a*).

Female.—Length about 3.3 mm. Color black; antennal segments 3–5 yellow basally; tarsi blackish brown; fore tibiæ often brownish yellow along middle of inner surface.

Head about two and one-half (2.44–2.64) times as long as wide; narrowest just behind eyes, widest just before the base, and without "neck-like constriction"; dorsal and lateral surfaces finely striate, sparsely set with short, subequal, inconspicuous spines; vertical bristles slightly shorter than the postocular, which are about one and one-half times as long as eyes; vertex conical, produced, apex overhanging insertion of antennæ. Eyes large, prominent, bulging, finely faceted, distance across them almost equal to greatest width of head. Ocelli small; anterior ocellus occupying extreme vertex; posterior ocelli nearly opposite centers of eyes and slightly removed from their inner margins. Antennæ slender, eight-segmented, about 1.4 times as long as head; segments 3–5 clavate; 6 and 7 sub-cylindrical, pedicellate; 8 lanceolate; segments 1 and 2 nearly concolorous with body, 2 slightly paler apically; segment 3 yellow, apical sixth clouded with black; segments 4 and 5 with respectively their basal two-thirds and two-fifths yellow; remainder of antenna concolorous with body; sense cones long, slender, transparent, scarcely distinguishable from the antennal bristles; formula: 3,0–1; 4, 1–2; 5, $1-1^{+1}$; 6, $1-0^{+1}$; 7 with one on dorsum near apex, and 3 and 4 each with a sub-apical one on ventral surface. Mouth cone short, broadly rounded, reaching about to middle of prosternum.

Prothorax very slightly shorter than greatest width of head, and (including coxæ) about twice as wide as long, with a prominent median groove; surface faintly reticulate; usual spines all present, the pair at the posterior angles much the longest, nearly as long as the postoculars. Pterothorax sub-rectangular, slightly wider than long, and slightly broader than prothorax; anterior corners projecting slightly beyond the lateral margins. Wings present, short, reaching to posterior margin of sixth abdominal segment. Legs without conspicuous spines; fore femora slightly more than half as wide as greatest width of head; fore tarsi armed each with a short broad tooth.

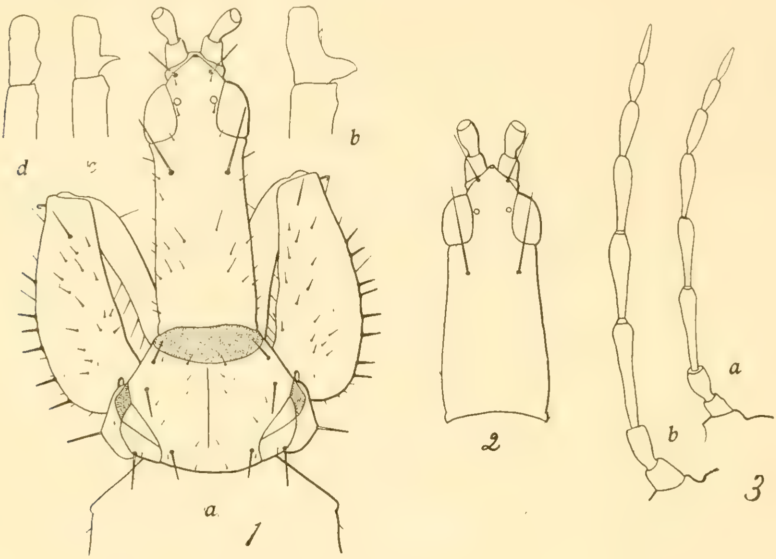

FIG. 9.

1.—Idolothrips armatus sp. nov.; a, head and prothorax, male, x67; b, c, left fore tarsus, male, x93, showing variations; d, left fore tarsus, female, x93. (J. D. H., del.)

2.—Idolothrips armatus sp. nov., female, head, x67. (J. D. H., del.)

3.—a, Idolothrips armatus sp. nov., female, right antenna, x67; b, Idolothrips tuberculatus sp. nov., female, right antenna, x67. (J. D. H., del.)

Abdomen long, very slender, lanceolate, about 1.4 times as wide as pterothorax, and about four times as long as its greatest width; widest at segment 2, thence tapering evenly to base of tube. Tube slightly shorter than head, tapering evenly from base to apex; surface not spinose; terminal bristles much shorter than tube, brown or black at base. Spines on segments 5–8 one-third as long as tube; those on segment 9 nearly as long as tube.

Measurements:—Total length 3.0–3.6 mm.; head, length .56 mm., width .22 mm.; prothorax, length .22 mm.; width (including coxæ) .40 mm.; pterothorax, width .45 mm.; abdomen, width .61 mm.; tube, length .50 mm.; width at base .118 mm.; at apex .059 mm. Antennæ: 1, 53μ; 2, 76μ; 3, 165μ; 4, 140μ; 5, 123μ; 6, 104μ; 7, 73μ; 8, 78μ; total, .81 mm.; width, 42 μ.

Male.—Larger than female (length 3.3–3.9 mm.). Fore tarsi yellow; fore tibiæ yellow along middle of inner surface, becoming concolorous with body laterally and basally.

Head about 2.8 times as long as wide (2.77–2.92), widest across eyes; genal spines inconspicuous, the pair just behind the eyes largest. Eyes larger and

more bulging than in female, the head flaring out to receive them. Antennæ slightly less than 1.4 times as long as head (usually about 1.38).

Prothorax slightly longer than greatest sub-basal width of head. Fore femora usually as wide as, or slightly narrower than, head, armed on basal half of outer surface with about seven prominent, stout, black, and nearly equidistant spines, and on outer surface near apex with a long, stout, downwardly-hooked spine; fore tarsi provided either with a long and very stout straight tooth or with a shorter and much more slender curved one.*

Abdomen more slender than that of the female, slightly narrower than pterothorax, and about five times as long as wide; tapering evenly from base to tube. Tube about .65 as long as head, and excepting a short basal widening, tapering evenly to apex.

Measurements:—Total length 3.3–3.9 mm.; head, length .60 mm., width .218 mm.; prothorax, length .224 mm., width (including coxæ) .45 mm.; pterothorax, width .52 mm.; abdomen, width .51 mm.; tube, length .37 mm., width at base .101 mm., at apex .059 mm. Antennæ 1, 53μ; 2, 75μ; 3, 173μ; 4, 151μ; 5, 136μ; 6, 107μ; 7, 75μ; 8, 78μ; total .84 mm.; width 42μ.

Described from eight females and eight males, all from Illinois, as follows: Carbondale, May 19, June 20, in galls of Gnorimoschema gallæsolidaginis on Solidago canadensis (C. A. Hart, J. D. H.); Havana, June 27, in miscellaneous sweepings (C. A. H.); Pulaski, May 24, in woodland sweepings (C. A. H.); Urbana, Aug. 7, on Plantago rugelii (J. J. Davis).

This species is closely related both to I. africana Trybom and I. coniferarum Pergande. From the former, it may easily be distinguished by the shape of the tube, which is fully four times as long as its greatest basal width, while in africana the tube is "am Grunde ein Drittel so breit wie lang." From coniferarum, of which Dr. Hinds gives four figures, it differs most noticeably in the shape and length of the head, the length of the vertical and postocular bristles, and in the form of the antennal segments. The male of armatus, furthermore, has a strong, hooked subapical spine on the outer surface of the fore femora, in addition to the stout and nearly equidistant spines which have suggested the species name.

Idolothrips tuberculatus sp. nov. (fig. 9, 3*b*; fig. 10).

Female.—Length 3.8–4.3 mm. Color coal black, without markings; antennal segments 3–6 yellow basally; tarsi and apices of tibiæ brown.

Head slightly more than twice as long as wide, slightly narrowed just behind eyes and at extreme base, widest across eyes; dorsal and lateral surfaces finely striate; cheeks with many prominent, stout, black spines, of which a postocular and a sub-basal pair are usually longer; vertical bristles shorter than the postocular, which are about equal in length to eyes; vertex conical, produced, apex overhanging insertion of antennæ. Eyes large, prominent, bulging, finely faceted. Ocelli moderate, their diameter about twice as great as that of facets of eyes; anterior ocellus occupying extreme vertex; posterior ocelli opposite anterior third of eyes and slightly removed from their inner margins. Antennæ slender, eight-segmented, about one and one-half times as long as head; segments

*The size of the tarsal tooth apparently depends upon the degree of enlargement of the fore femora.

3–5 clavate; 6 subclavate; 7 sub-cylindrical, pedicellate; 8 lanceolate; segments 1 and 2 nearly concolorous with body, 2 slightly paler apically; segments 3–6 with respectively their basal two-thirds, three-fifths, two-fifths, and one-third, pale yellow; remainder of antenna dark blackish brown; all sense cones long and slender; formula as for I. armatus sp. nov. Mouth cone short, broadly rounded, reaching about to middle of prosternum.

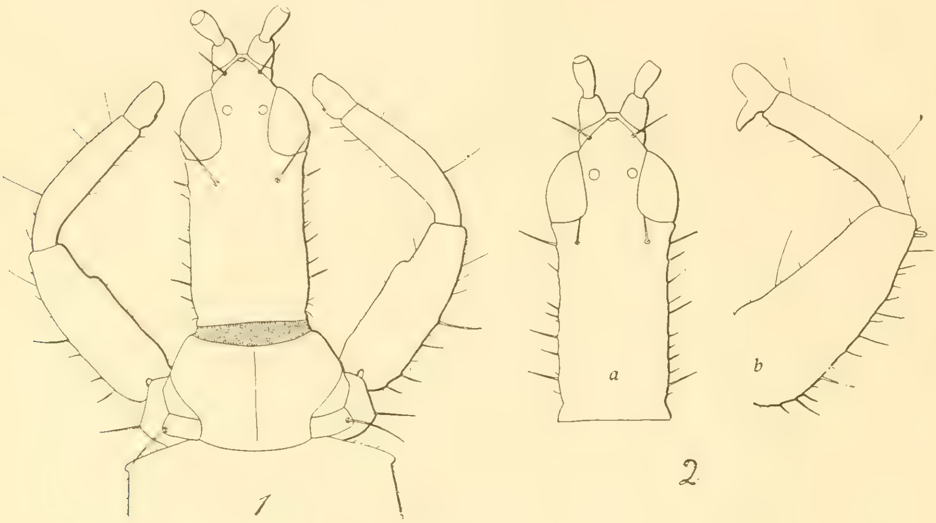

FIG. 10.

1.—Idolothrips tuberculatus sp. nov., female, head and prothorax, x60. (J. D. H., del.)

2.—Idolothrips tuberculatus sp. nov., male, a, head, x67; b, right fore leg, x60. (J. D. H., del.)

Prothorax about as long as width of head, and (including coxæ) about twice as wide as long, with a median groove; surface reticulate; coxal spine and the two notal pairs near the posterior angles, prominent; all others lacking (?). Pterothorax sub-rectangular, about two-thirds as long as wide, and slightly broader than prothorax. Wings large, powerful, closely fringed, and washed with brown at base; principal vein of both pairs extending about to middle; fore wings with a blackish brown area in front of the black anterior vein, with the sub-apical fringe on the posterior margin double for about forty hairs, and with the most distal of the three basal spines fully as long as the prothorax. Inner lower surface of fore femora each with a large prominent semicircular projection; fore tarsi armed each with a short, acute, hooked tooth, the apex directed forwards on a line parallel to the tarsus.

Abdomen large, heavy, lanceolate, slightly wider than pterothorax and about 3.3 times as long as its greatest width; widest at segments 2 and 3, thence tapering nearly evenly to base of tube. Tube slightly shorter than head, tapering evenly from base to apex; surface not spinose; terminal bristles shorter than tube, black at base. Spines on segment 9 about equal in length to tube, brownish; spines on basal abdominal segments short, colorless.

Measurements:—Total length, 3.8–4.3 mm.; head, length .64–.70 mm., width .28 mm.; prothorax, length about .27 mm., width (including coxæ) .55 mm.; pterothorax, width .65 mm.; abdomen, width .75 mm.; tube, length .60 mm., width at base .137 mm., at apex .07 mm. Antennæ: 1, 64μ; 2, 92μ; 3, 224μ; 4, 196μ; 5, 168μ; 6, 115μ; 7, 78μ; 8, 92μ; total, 1.02 mm., width 53μ.

Male.—Larger than female (length about 4.5 mm.). Fore tarsi brownish yellow; fore tibiæ blackish brown, darker basally.

Head longer, narrower, and wider across eyes than that of female; genal spines longer and much more prominent; postocular bristles less than half as long as eyes. Eyes larger, more bulging, the head flaring out to receive them.

Prothorax longer than width of head, less than twice as wide as long; anterior lateral margins broadly and evenly rounded. Inner surface of fore femora without trace of a tubercle; outer surface near apex with a long, stout, downwardly-hooked spine; fore tarsi armed each with a very large, stout tooth.

Abdomen slender, tapering evenly from base to tube. Tube .73 as long as head, tapering evenly from base to apex. Segment 9 with a pair of strong, prominent, downwardly-directed, brown spines on its ventral surface.

Measurements:—Total length 4.52 mm.; head, length .74 mm., width .26 mm.; prothorax, length .35 mm., width (including coxæ) .60 mm.; pterothorax, width .70 mm.; abdomen, width .66 mm.; tube, length .54 mm., width at base .123 mm., at apex .078 mm. Antennæ: 1, 73μ; 2, 98μ; 3–8?

Described from four females and one male, all from Illinois, as follows: White Heath, Aug. 26, 3 ♀'s and 1 ♂, on white oak (C. A. Hart); Bosky Dell, Oct. 22, ♀, on white oak (L. M. Smith).

This species is a very distinct one, readily distinguishable from its congeners by the femoral tubercle and tarsal tooth of the female, and by the armature of the ninth abdominal segment of the male. It is the largest known North American species of the order east of the Rocky Mountains.

Recent Deaths.

William Harris Ashmead, Honorary Fellow of the Entomological Society of America, died in Washington, D. C., October 17th, 1908. Mr. Ashmead has been a tireless worker in entomology and his name will be permanently connected with the science of American entomology, especially in the Hymenoptera, which was the field of his work for many years.

James Fletcher, Entomologist of the Central Experimental Farms of the Dominion of Canada, and one of the best known of American entomologists died in Montreal, Canada, November 8th, 1908. He has been a fellow and one of the active officers of the Entomological Society of America and one of the strongest friends and an ardent supporter of the Annals.

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NOTICE TO MEMBERS AND CONTRIBUTORS

The Annals of the Entomological Society of America will be published by the Society quarterly and will include the Proceedings of the Annual meetings and such papers as may be selected by the Editorial Board.

Papers may be submitted to any member of the Editorial Board and should be as nearly as possible in the form desired as final, preferably typewritten, and illustrations must be finished complete ready for reproduction. Plates must not exceed 5 x 7 inches unless intended to fold. In general, papers to be accepted must be original, complete and previously unpublished and, except in connection with the proceedings, it will not be the policy to publish preliminary announcements or notes. Authors will be allowed fifty reprints gratis and additional copies at cost to the Society.

The annual subscription to members is $1.00 in addition to the annual dues and may be sent to the Secretary-Treasurer. Mr. J. Chester Bradley, Cornell University, Ithaca, N. Y.

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